US Army Corps
of Engineers
Construction Engineering
Research Laboratories

USACERL Technical Report 97/08
October 1996

Evaluation of Pen-Based Systems for Use at Construction Offices

by
Glenn A. Rasmussen and E. William East

The construction industry uses many small computer systems with pen-based user interfaces for a variety of inspection, inventory control, scheduling, and forms processing tasks. Improvement in size, capacity, cost, and reliability of handheld computer equipment has made these tools practical for construction office use.

These tools are considered to be very promising platforms for the transfer of U.S. Army Corps of Engineers technology through a cooperative project between USACERL and Indiana State University called the Construction Technology Transfer Center.

For this phase of research, a survey of private industry was conducted using a Sources Sought Notice published in the Commerce Business Daily. Following the survey, an evaluation matrix was developed and the respondents were evaluated. This report presents the results of the evaluation of commercial pen-based computing equipment for use at construction offices.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1996	Final

4. TITLE AND SUBTITLE
Evaluation of Pen-Based Systems for Use at Construction Offices

5. FUNDING NUMBERS
CW
32948

6. AUTHOR(S)
Glenn A. Rasmussen and E. William East

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Construction Engineering Research Laboratories (USACERL)
P.O. Box 9005
Champaign, IL 61826-9005

8. PERFORMING ORGANIZATION REPORT NUMBER
TR 97/08

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Headquarters, U.S. Army Corps of Engineers (HQUSACE)
20 Massachusetts Avenue, NW
Washington, DC 20314-1000

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The construction industry uses many small computer systems with pen-based user interfaces for a variety of inspection, inventory control, scheduling, and forms processing tasks. Improvement in size, capacity, cost, and reliability of handheld computer equipment has made these tools practical for construction office use.

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14. SUBJECT TERMS
computer systems
construction automation
evaluation

15. NUMBER OF PAGES
54

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

Foreword

This study was conducted for Headquarters, U.S. Army Corps of Engineers (HQUSACE) under civil works project 381, "Construction Technology Transfer"; Work Unit 32948, "Construction Technology Transfer Center."

The work was performed by the Business Processes Division (PL-B) of the Planning and Management Laboratory (PL), U.S. Army Construction Engineering Research Laboratories (USACERL). The USACERL principal investigator was E. William East. Moonja P. Kim is Acting Chief, CECER-PL-B and L. Michael Golish is Operations Chief, CECER-PL. The USACERL technical editor was Linda L. Wheatley, Technical Resources Center.

COL James T. Scott is Commander of USACERL, and Dr. Michael J. O'Connor is Director.

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1 Introduction

Background

Many construction companies do not thoroughly understand how computer-aided technologies can improve the accuracy, efficiency, and production of construction operations. The slow adoption of new technologies may be due to the difficulty of using computer equipment in the traditional desk-top unit and the training required to effectively use the equipment. Small to medium sized contractors in particular are often short of professional staff who can advocate the implementation of new technologies. In addition, owners and managers within these companies are often unaware of computer applications in construction work and general business practice. This lack of awareness can lead to a lack of understanding of the value of newer technologies and a reluctance to adopt them.

The U.S. Army Corps of Engineers has been in the forefront of effectively using computing technology to support construction activities. The Corps has developed mechanisms such as the Construction Microcomputer Users' Group and, soon, the Resident Management System (RMS) to directly support construction office activities. As part of the Corps' research and development mission, USACERL has also contributed to the use and distribution of advanced technology to the construction site both as a facilitator of technology exchange and through prototype products and systems.

Objectives

USACERL is working with Indiana State University's (ISU's) School of Construction Technology on a cooperative construction technology transfer project called the Construction Technology Transfer Center (CTTC). The CTTC was created to: (1) assess the current technologies and management tools used by small and medium sized construction companies, (2) provide technology transfer support to small and medium sized contractors for Corps' developed technologies, and (3) enhance the competitiveness of these contractors.

In partial fulfillment of this project and the purpose of the CTTC, the objectives of this study were to: (1) identify sources of expertise in pen-based computing for construction office applications, (2) develop a review process that would rank the products produced by the vendors identified, and (3) determine which set of vendor products most closely matched construction office requirements.

Approach

A set of functional requirements was defined based on the authors' knowledge of commercially available construction software and general level of technology. Private industry vendors were surveyed through the Sources Sought Notice process. Vendors responding to the survey were evaluated based on the functional requirements and other relevant information.

Scope

The results of this project are applicable to many offices that may be engaged in quality control or quality assurance, documentation of job progress, and safe working conditions. The resulting data are easily transferred from the pen-based computer systems of the Corps of Engineers to the computer systems of other owner-represented agencies and private construction companies.

Mode of Technology Transfer

The results of this research will be used to: (1) identify industry partners who may assist in the cooperative development of commercial products based on existing Corps prototypes for construction offices and (2) identify existing commercial systems that may be directly applied to construction office activities. If funded, future phases of this research will develop specific technology transfer activities and will include the delivery of these programs through ISU's CTTC.

2 Pen-based Construction Applications

Requirements

Construction office desk-top automation supports a number of tasks that can be generally categorized as: (1) evaluating checklist information, (2) documenting work accomplished, (3) integrating cost and time control systems, and (4) including support for computerized construction plans and specifications. Additionally, adapting these tasks for use in the palm-top equipment that may be carried onto the construction site is needed. To ensure that commercial products have the capability to support these tasks, a variety of specific items were identified as possible application areas.

For the evaluation of checklist tasks, vendors were asked to submit systems that included any of the following domain-specific areas: design quality checklists, frequently encountered quality assurance problems, safety procedures and manuals, and environmental compliance checklists. For tasks related to documenting work accomplished, prototypes needed to have straightforward user interfaces that used a minimum of handwriting recognition.

Another requirement was that vendor systems should show how project scheduling and project estimating data were incorporated with checklist tasks. Drawings produced in Computer Aided Design (CAD) systems were also considered as a component of the possible program. In the palm-top construction system, CAD drawing overlays would typically be used to capture information generated on the job site.

To transfer data and obtain data from other sources, transmission of data via telefacsimile (fax), modem, and input/output (I/O) port connection was considered. The means by which the user entered data was also carefully considered. For example, while the translation of handwriting to typed letters has improved, the typical user became frustrated by assisting the computer to determine the differences between the letter "l" and the number "1." To ensure compatibility with the widest possible set of hardware and software, the application had to use the Intel®-type microchips running the Disk Operating System (DOS) 3.1 or higher and Windows 3.1 or higher, with data stored in a standard query language (SQL)-compatible relational database structure. A usage tutorial also needed to be available for on-line help.

Finally, the type of development envisioned for the palm-top equipment is that of a collaborative development through an existing commercial vendor. Having a collaborative arrangement allows the commercial vendor to develop, market, and support a product that meets the specific requirements of the construction office at significantly lower cost. However, the resources required to develop and support a widely accepted, practical commercial application are beyond the scope of the ISU technology transfer project.

Wireless Communications

Wireless communications were discussed as a way of providing a real time environment for the proposed pen-based application. The advantages and disadvantages of Infrared Data Communications (IDC), wireless Local Area Networks (LANs), cellular modems, and Radio Frequency Data Communications (RFDC) were investigated. However, these issues are not directly related to the actual application and are data I/O and transfer issues that do not impact the application functionality.

Based on preliminary data, IDC was not considered a viable data transfer method for the amount of data required to be transmitted. IDC requires direct line of sight for data transmission, which could present problems in certain environments (i.e., the user's office or work space is separated by walls or partitions from the computer where the main application is resident; or the lighting in the work space is sifted toward the infrared end of the spectrum, thereby interfering with transmission patterns because of high infrared saturation).

Methods now used for data transmission are wireless or cellular nodes on existing LANs, RFDC, and cellular modems. RFDC could either spread the spectrum, where data is transmitted over a wide band of frequencies, or be single channels, where data is transmitted on a single frequency assigned by the Federal Communications Commission (FCC). Cellular modems using Personal Computer Mobile Card Interface Association (PCMCIA) technology are also viable.

Wireless or cellular nodes are indicated for office environments because LANs are a proven technology generally available in the environments where the proposed software would be used. Both RFDC and cellular modems could be used in construction site environments, but RFDC has a limited range of 0.5 to 0.75 miles, depending on the site and building materials. The cellular modems have a range equal to any cellular telephone, but large data transfers could be expensive, and data transmission software would have to have extensive error checking capabilities.

Sources Sought Notice

Using existing guidelines considered above, a Sources Sought Notice was published in the Commerce Business Daily (CBD) on 2 November 1994. The notice detailed the basic functional requirements of a pen-based software system and asked respondents to submit a package for review and consideration. The sources were being sought as potential partners in a collaborative work agreement with USACERL. The Sources Sought Notice read:

> Glenn Rasmussen, 217/352-6511, Extension 7535, or Bill East, 217/373-6710. The Design and Construction Team of the U.S. Army Construction Engineering Research Laboratories (USACERL) is seeking sources with expertise in pen-based inspection related software development for a future collaborative development effort to support design and construction quality assurance processes. The objective of this development is a pen-based integrated system containing design quality checklists, frequently encountered quality assurance problems, safety procedures and manuals, keywords, project scheduling data, project estimating data, and environmental compliance checklists that may be linked to plans and specifications. Computer Aided Design (CAD) system overlays shall be utilized to capture graphical information generated on the job site. Resulting data shall be transmittable via fax, modem, or I/O port connection. The application software shall be compatible with DOS 3.1 or higher and Windows 3.1 or higher, with data stored in a standard query language (SQL) compatible relational database structure. A usage tutorial shall be available as on-line help. Respondents should provide a description of organizational resources and programming capabilities, a list of previous clients with points of contact and demonstration diskettes of existing pen-based inspection software that is currently being marketed. This is not a request for proposal and is not to be construed as a commitment by the government to issue a solicitation or ultimately award a contract. Any cost incurred as a result or response to this announcement shall be borne by the offeror and will not be charged to the government for reimbursement. All questions should be addressed to Mr. Glenn Rasmussen at 217/352-6511, extension 7535, or Mr. Bill East at 217/373-6710. Any and all responses shall be submitted to USACERL, P.O. Box 9005, Champaign, IL 61826-9005 within forty-five days after publication of this notice.

3 Evaluation Process

A Lotus Notes™ application program was developed to support the evaluation of each of the respondents. Three types of information were contained in the application: initial company information, application-specific criteria, and company viability criteria.

Initial Company Information

The first type of information, obtained directly from each vendor package, included basic vendor information including: name, address, point of contact, voice and fax phone numbers, Internet E-mail address (if available), and a brief comment on the completeness of the submission.

Application-Specific Criteria

The second type of information contained in the Lotus Notes™ application was a response form that allowed evaluation of the submission to begin. Using this application, it was possible to determine which of the systems met the requirements described in Chapter 2. The categories used were: (1) Database—dBase, Access, Oracle, etc., (2) User Added Data Tables, (3) Design Quality Checklists, (4) Frequently Encountered Q/A Problems, (5) Safety Procedures and Manuals, (6) Searching with Keywords, (7) Project Scheduling Data, (8) Project Estimating Data, (9) Environmental Compliance Checklists Linkage, (10) Editable Computer Aided Design Overlays, (11) DOS/Windows Compatibility, (12) Pen Compatibility, (13) User Defined Reports, (14) Multi-user System, and (15) Wireless Data Transfer.

Each element was presented in a table containing the criteria element and three possible answers: yes, no, or unknown. A yes/no answer was entered in the table based on whether the submission demonstrated either the element or a close approximation. Unknown was chosen when there was no clear way of determining whether that element was present or not. Table 1 is a sample of this evaluation criteria form. When completed, Table 2 gives more detailed information for criteria listed in Table 1. Scoring was 1 if yes, -1 if no, and 0 if unknown.

Table 1. Evaluation criteria form.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc.*			
2. User Added Data Tables			
3. Design Quality Checklists			
4. Frequently Encountered Q/A Problems			
5. Safety Procedures and Manuals			
6. Keywords			
7. Project Scheduling Data *			
8. Project Estimating Data *			
9. Environmental Compliance Checklists			
10. Editable Computer Aided Design Overlays *			
11. DOS/Windows Compatibility			
12. Pen Compatibility			
13. User Defined Reports			
14. Multi-User System			
15. Wireless Data Transfer*			

Table 2. Evaluation criteria reference form.

Number	Name	Version	Manufacturer
1*			
7*			
8*			
10*			
15*			

Elements 11 and 12 (DOS/Windows Compatibility and Pen Compatibility) were deemed to be critical. A No or Unknown for either of these elements was grounds for elimination from further consideration. While the basic capabilities of being Intel-based and pen-compatible were established, which specific set of software and hardware used was not a concern. While the software/hardware information was captured in the review process, scoring did not include these factors.

Company Viability Criteria

In evaluating potential partners for development of construction office applications, the maturity of the company was considered. A multidimensional set of criteria was established to evaluate the ability of the company not only to develop potential collaborative products but also to market, distribute, and support those tools. The criteria used were: (1) number of employees, (2) number of office locations, (3) variety of exiting customer base, (4) diversification of product line, (5) in-house research and development (R&D) facilities, (5) average annual sales for the past 5 years, (6) average annual profit for the past 5 years, (6) current debt to asset ratios, and (7) age of the firm.

Number of Employees

The employee criterion was ranked according to the following formula: one point awarded for companies with between one and 49 employees, two points for companies with between 50 and 99 employees, three points for companies with between 100 and 199 employees, and four points for companies with 200 or more employees.

Number of Locations

Companies were given more points if they had offices in more than one city. The following formula was used: single-site companies were given one point, companies with offices in two or three cities were given two points, and companies with offices in four or more cities were awarded four points.

Customer Base

The importance of having a variety of different customers was reflected in the "customer base" criterion. For each of the following customer categories one point was awarded: Federal government (FG), state government (SG), local government (LG), private industry (PI), and retail (R) sectors. A maximum of five points could, therefore, have been awarded to each company.

Diversification

A company with more than one product was felt to be more viable than a company that relied on a single product or product line. One point was given to a company if that company had more than a single product line. One point was subtracted if the company relied on only one product line.

In-house R&D

Companies with in-house R&D departments were considered to have a better long-term growth potential than companies that had no such department. One point was awarded to companies with an R&D office. One point was subtracted from the score of companies that did not have an R&D office.

Average Annual Sales

Companies with higher average annual sales volume over the past 5 years were also considered more viable than start-up companies or those firms with low sales volume. The following formula was used to determine the number of points awarded for this criterion: one point was awarded for sales volumes of less than $500,000, two points for sales volumes of between $500,000 and $999,000, three points for sales volumes of between $1,000,000 and $9,999,000, four points for sales volume of between $10,000,000 and $49,999,000, and five points for sales volume of more than $50,000,000.

Average Annual Profit

In addition to annual sales volume, a company needed to show that the product being sold was making a profit. The formula used to award points for this criterion was: minus two points for less than 5 percent profit, minus one point for between 5 and 5.9 percent profit, zero points for between 6 and 6.9 percent profit, one point for between 7 and 7.9 percent profit, two points for between 8 and 8.9 percent profit, and three points for over 9 percent profit.

Current Debt to Asset Ratio

The current debt to asset ratio was used as a measure to evaluate the ability of the company to weather possible difficult financial times and also as a measure of the company's need for a short-term versus long-term profit. The following formula was used to score against this criteria: two points for less than 20 percent, one point from 20 percent to less than 25 percent, zero points from 25 percent to less than 33 percent, minus one point from 33 percent to less than 45 percent, and minus two points for companies with more than 45 percent or greater.

Organizational Age

Because one of the gauges of a company's success is how long the company stays in business, the age of the company was assessed as a separate criterion. The following formula was used to evaluate companies against the criterion: minus two points for less than 1 year, minus one point from 1 year to less than 3 years, zero points from between 3 years and less than 5 years, one point from between 5 years to less than 7 years, two points from 7 years to less than 10 years, and three points for 10 years or more.

The scoring of the criteria elements was accomplished by evaluating the organizational resources listed on the submissions, researching Standard and Poors online, and contacting the companies directly for those elements not found elsewhere. Table 3 is a sample of the company viability form.

Table 3. Company viability form.

Viability Criteria	Values	Points
Employees		
Locations		
Customer Base*		
Diversification		
In-house Research and Development		
Average Annual Sales Last 5 Years		
Average Annual Profit Last 5 Years		
Current Debt to Asset Ratio		
Organizational Age		

4 Description of Submissions

The respondents' submissions fell into three categories: (1) full and complete, (2) incomplete, and (3) correspondence. A complete submission had the organizational resources well documented and a demonstration diskette of the respondent's software that could be run on a Compaq Concerto pen-based notebook computer. An incomplete submission was most often missing the demonstration diskette. Correspondence covered several lines of inquiry, most often asking for more information regarding the CBD announcement.

Full Submissions

Galaxy Scientific Corporation

Galaxy presented ALERT, developed for Federal Aviation Administration (FAA) Aviation Safety Inspectors in inspecting commercial passenger aircraft. The application allows online access to inspector-required documentation, Federal Acquisition Regulations (FARs), and the Airworthiness Inspectors Handbook. These documents are equivalent to Corps of Engineers Guide Specifications. A videotape included as part of their submission had a visual demonstration of an inspector using ALERT.

The demonstration diskettes covered fire and emergency safety issues. Elevations of the Lockheed L-1011-500 were shown with corresponding detailed views and the safety inspection procedures to be checked or carried out during an inspection of the detail. This application uses many inspection processes that appear to correlate closely with the quality assurance inspections CTTC wants to develop.

Galaxy also sent a copy of the report that they submitted to the FAA regarding their research into pen-based computing. They included justification for exclusive use of pen-based computers, but, in the end, their application can be run on a number of computer platforms (i.e., desktop, notebook, or pen computers).

Angle Incorporated

Angle submitted an on-board audit application called Toppen/Track, which is used by the U.S. Navy. After installing the application, all of the framework was present, but much of the data that would explain its functions were missing. The lack of functionality seemed to indicate a flawed installation because the icon within Windows was titled, "Pen-Based application." Nothing was entered in the matrix at that point in time because of this problem.

After Angle was called, it was determined that the application had been started incorrectly. All the data were available but had to be accessed in a somewhat different manner then was obvious from the Windows structure. This problem proved to be a function of the demonstration diskette that was provided. The Toppen/Track application had been abbreviated for the diskette, and that hampered some of the normal linkages.

An X was placed in the Yes box of the database criteria element even though the application seemed to be programmed to function using Microsoft Access. The level of functionality indicates that Angle could very easily produce an application to use SQL data structure. Angle's organizational resource submission indicated expertise in SQL programming.

Brent Rauhut Engineering, Inc.

Brent Rauhut Engineering submitted a pavement inspection application called ADRES that is probably similar to PAVER.* After installation, only the initial screen could be accessed from the DOS prompt. The application is not Windows compatible. The pen would not function and the application would not work past the initial screen. The application had to be installed manually from DOS. The evaluation table was completed based on the documentation.

This respondent was eliminated because the product was not Windows or pen-based compatible.

Integrated Planning Systems

Integrated Planning Systems provided a real demonstration diskette with a canned demonstration of their application GeoFirma. It was an integrated package that allowed the user to design custom forms for each inspection type. Instead of using

*A pavement maintenance management tool.

CAD layers, they presented a picture on which notes could be written, an equivalent in concept to the use of CAD drawings for markup. The evaluation table was completed based on the observed demonstration and data from their organizational resources submission.

Further investigation of Integrated's capabilities is warranted.

Sentel

Sentel provided two demonstration applications. One was National Aeronautics and Space Administration (NASA) QAPDC, an inspection application dealing with Work Authorization Documents (WADs). It covers sequences used by NASA inspectors to maintain quality control in the space shuttle program. It has scheduling functions that interface with NASA's management systems to provide a rapid response to quality control issues. The second application was Facility Assessment, a facility inspection application that is used to monitor maintenance and environmental compliance at NASA and their contractors' facilities.

After completing the evaluation table, NASA officials in charge of both applications were contacted for their opinions of the systems' functionality. All comments received were positive. NASA officials were happy with the operation of both applications and their interface to standard NASA systems.

Sentel also submitted their research paper covering pen-based computers with some useful information that can referenced in the future.

Hyper Project

Hyper Project is a developer of Macintosh Software. They submitted just to let USACERL know that they are Macintosh pen-based developers. So Hyper Project was eliminated from consideration because their demonstration diskette was not DOS/Windows compatible.

Eiger Technical Systems

Eiger provided two applications. The first application was called Mobile Medical Center, which appears to be a pen-based application that can be used from admitting to discharge by the staff of a medical facility. Graphically operated diagnostic tools allow the user to touch a body part on an image, and the correct name will appear in a box. A patient also can enter information on an electronic form. This application shows a very good understanding of both Windows and pen computing.

The application uses Fox-Pro, so it does not show SQL compatibility, but the capabilities statement lists SQL expertise.

The second application was for signature verification. To store a signature, the user writes his signature six times. That stores a composite signature that can be used to verify the user's signature in the future. The application was tried several times and found to be functionally adequate. It was able to verify the tester's signature, but it would not verify someone else trying to copy the tester's signature.

Although Eiger's application did not have a number of the features to be evaluated, they seem to have the expertise to develop them.

KPMG Peat Marwick, LLP

KPMG Peat Marwick provided an inspection application, Condition Assessment Information System(CAIS), which was a canned demonstration that would not run in Windows, although it has Windows in the application according to the documentation. They also provided another application that was described as a demonstration generator.

Installation of both programs was attempted three times without success. The company POC was contacted for further instructions regarding the installation. Nothing was resolved, and the applications could not be run. KPMG Peat Marwick was eliminated because the applications did not run in Windows or in DOS.

Pen Time, Inc.

Pen Time submitted two applications that were loaded on a pen computer, a Fujitsu 325, which uses a 386/25SX processor. Waiting for screens to change and data to become available on this computer reinforced the need for computers that use at least 486/33 processors. Anything slower would not do well in the field.

Pen Time shows a good knowledge of pen computing, but they have only peripherally presented applications related to inspection. Trauma Flow requires the user to make decisions based on questions presented to the user, but the applications have little depth. Road Service has parts lists and graphics that could be interpreted as demonstrating some of the required knowledge. Pen Time's organizational capabilities submission listed expertise in most evaluation categories, but the applications did not show this expertise.

Partial Submissions

MAR Inc.

MAR's submission indicated that they wanted to do a live demonstration because they contend that their application does not lend itself to demonstration diskettes. MAR's POC was contacted and told that there could be no live demonstration because of the fairness issue in the evaluations.

American Management Systems

American Management Systems' submission was incomplete. An organization capabilities submission was sent but no demonstration software. The submission arrived too late for American Management Systems to correct this problem.

Correspondence Relating to the CBD Announcement

Correspondence came from a number of sources regarding the CBD announcement. Some sought additional information, some asked when the RFP would be published, and several pitched their own solutions to the problem. All correspondence was answered by stating that all available information could be found in the text of the announcement.

5 Evaluation of Full Submissions

Galaxy Scientific Corporation

William B. Johnson, Ph.D., Vice President, Information Division, 2310 Parklake Drive, Suite 325, Atlanta, Georgia 30345; telephone (404) 491-1100; fax (404) 491-0739.

Table 4. Evaluation of Galaxy Scientific Corporation submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase; Access, etc.*	X		
2. User Added Data Tables			X
3. Design Quality Checklists			X
4. Frequently Encountered Q/A Problems	X		
5. Safety Procedures and Manuals	X		
6. Keywords	X		
7. Project Scheduling Data *		X	
8. Project Estimating Data *		X	
9. Environmental Compliance Checklists	X		
10. Editable Computer Aided Design Overlays *	X		
11. DOS/Windows Compatibility	X		
12. Pen Compatibility	X		
13. User Defined Reports			X
14. Multi-User System	X		
15. Wireless Data Transfer*		X	

Evaluation Score: 6

Table 5. Galaxy Scientific Corporation reference information.

Number	Name	Version	Manufacturer
1	Access	Unknown	Microsoft
7	N/A		
8	N/A		
10	AutoCad	Windows	Autodesk
15	N/A		

Table 6. Galaxy Scientific Corporation viability evaluation.

Viability Criteria	Values	Points
Employees	350	4
Locations	8	3
Customer Base*	FG / PI	2
Diversification	Yes	1
Inhouse Research and Development	Yes	1
Average Annual Sales Last 5 Years		1
Average Annual Profit Last 5 Years		-2
Current Debt to Asset Ratio		-2
Organizational Age	8 years	2

Viability Total Score: 10

Angle, Inc.

David J. Kline, 7406 Alban Station Court, Suite A112, Springfield, Virginia 22150; telephone (703) 866-0060; fax (703) 866-0063.

Table 7. Evaluation of Angle, Inc. submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc. *	X		
2. User Added Data Tables		X	
3. Design Quality Checklists			X
4. Frequently Encountered Q/A Problems	X		
5. Safety Procedures and Manuals			X
6. Keywords	X		
7. Project Scheduling Data *		X	
8. Project Estimating Data *		X	
9. Environmental Compliance Checklists			X
10. Editable Computer Aided Design Overlays *			X
11. DOS/Windows Compatibility	X		
12. Pen Compatibility	X		
13. User Defined Reports			X
14. Multi-User System	X		
15. Wireless Data Transfer *			X

Evaluation Score: 3

Table 8. Angle, Inc. reference information.

Number	Name	Version	Manufacturer
1	Paradox	Unknown	Borland
7	N/A		
8	N/A		
10	N/A		
15	N/A		

Table 9. Angle, Inc. viability evaluation.

Viability Criteria	Values	Points
Employees	18	1
Locations	1	1
Customer Base*	FG / PI	2
Diversification	Yes	1
Inhouse Research and Development	Yes	1
Average Annual Sales Last 5 Years	1200K	3
Average Annual Profit Last 5 Years	0 (S Corporation)	-2
Current Debt to Asset Ratio	0.23	1
Organizational Age	4+	0

Viability Total Score: 8

Integrated Planning Systems

Don E. Nollett, Director of Marketing, 1620 Wilshire Drive, Suite 300, Bellevue, Nebraska 68005-6600; telephone (402) 293-9003.

Table 10. Evaluation of Integrated Planning Systems submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc. *	X		
2. User Added Data Tables			X
3. Design Quality Checklists			X
4. Frequently Encountered Q/A Problems			X
5. Safety Procedures and Manuals			X
6. Keywords	X		
7. Project Scheduling Data *	X		
8. Project Estimating Data *	X		
9. Environmental Compliance Checklists			X
10. Editable Computer Aided Design Overlays *	X		
11. DOS/Windows Compatibility	X		
12. Pen Compatibility	X		
13. User Defined Reports			
14. Multi-User System	X		
15. Wireless Data Transfer *			X

Evaluation Score: 8

Table 11. Integrated Planning Systems reference information.

Number	Name	Version	Manufacturer
1*	Access	Windows	Microsoft
7*	Proprietary		
8*	Proprietary		
10*	Autocad	Windows	Autodesk
15*	N/A		

Table 12. Integrated Planning Systems viability evaluation.

Viability Criteria	Values	Points
Employees	25	1
Locations	1	1
Customer Base*	FG / PI	2
Diversification	Yes	1
Inhouse Research and Development	Yes	1
Average Annual Sales Last 5 Years	2000K+	3
Average Annual Profit Last 5 Years	9.5%	3
Current Debt to Asset Ratio	0.315	0
Organizational Age	10	3

Viability Total Score: 16

Sentel Corporation Air and Space Division

Eric Adolphe, Director, Special Projects, 8455 Colesville Road, Suite 1200, Silver Springs, Maryland 20910; telephone (301) 495-9100; fax (301) 495-8982.

Table 13. Evaluation of Sentel Corp. Air and Space Division submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc. *	X		
2. User Added Data Tables			X
3. Design Quality Checklists	X		
4. Frequently Encountered Q/A Problems			X
5. Safety Procedures and Manuals	X		
6. Keywords			X
7. Project Scheduling Data *	X		
8. Project Estimating Data *	X		
9. Environmental Compliance Checklists	X		
10. Editable Computer Aided Design Overlays *	X		
11. DOS/Windows Compatibility	X		
12. Pen Compatibility	X		
13. User Defined Reports	X		
14. Multi-User System	X		
15. Wireless Data Transfer *			X

Evaluation Score: 11

Table 14. Sentel Corp. Air and Space Division reference information.

Number	Name	Version	Manufacturer
1*	Relational Database Expertise		Oracle, Informix
7*	Proprietary, Interfaces with NASA System		
8*	Proprietary, Interfaces with NASA System		
10*	Autocad	Windows	Autodesk
15*	N/A		

Eiger Technical Systems

Mark Lueker, Director, Advanced Projects, 1265 Van Horne Avenue, Suite 100, Hermosa Beach, California 90254; telephone (310) 376-1719.

Table 15. Evaluation of Eiger Technical Systems submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc. *	X		
2. User Added Data Tables			X
3. Design Quality Checklists		X	
4. Frequently Encountered Q/A Problems		X	
5. Safety Procedures and Manuals	X		
6. Keywords	X		
7. Project Scheduling Data *		X	
8. Project Estimating Data *		X	
9. Environmental Compliance Checklists		X	
10. Editable Computer Aided Design Overlays *		X	
11. DOS/Windows Compatibility	X		
12. Pen Compatibility	X		
13. User Defined Reports			
14. Multi-User System	X		
15. Wireless Data Transfer *		X	

Evaluation Score: -1

Table 16. Eiger Technical Systems reference information.

Number	Name	Version	Manufacturer
1	FoxPro	Unknown	Microsoft
7	N/A		
8	N/A		
10	N/A		
15	N/A		

Pen Time, Inc.

1632 Schulte Road, St. Louis, Missouri 63146; telephone (314) 997-1084; fax (314) 997-7290.

Table 17. Evaluation of Pen Time, Inc. submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc. *	X		
2. User Added Data Tables			X
3. Design Quality Checklists		X	
4. Frequently Encountered Q/A Problems			X
5. Safety Procedures and Manuals	X		
6. Keywords			X
7. Project Scheduling Data *		X	
8. Project Estimating Data *		X	
9. Environmental Compliance Checklists		X	
10. Editable CAD Overlays *		X	
11. DOS/Windows Compatibility	X		
12. Pen Compatibility	X		
13. User Defined Reports		X	
14. Multi-User System	X		
15. Wireless Data Transfer *		X	

Evaluation Score: -2

Table 18. Pen Time, Inc. reference information.

Number	Name	Version	Manufacturer
1*	Dbase	IV	Borland
7*	N/A		
8*	N/A		
10*	N/A		
15*	N/A		

Table 19. Pen Time, Inc. viability evaluation.

Viability Criteria	Values	Points
Employees	4	1
Locations	1	1
Customer Base*	LG / PI	2
Diversification	No	-1
Inhouse Research and Development	Yes	1
Average Annual Sales Last 5 Years	350K	1
Average Annual Profit Last 5 Years	0%	-2
Current Debt to Asset Ratio	0	2
Organizational Age	3.5	0

Viability Total Score: 5

Brent Rauhut Engineering, Inc.

Harold L. Von Quintus, President, 8240 Mopac, Suite 220, Austin, Texas 78759; telephone (512) 346-0870; fax (512) 346-8750.

Table 20. Evaluation of Brent Rauhut Engineering, Inc. submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc. *			
2. User Added Data Tables			
3. Design Quality Checklists			X
4. Frequently Encountered Q/A Problems			X
5. Safety Procedures and Manuals			X
6. Keywords		X	
7. Project Scheduling Data *		X	
8. Project Estimating Data *		X	
9. Environmental Compliance Checklists			X
10. Editable Computer Aided Design Overlays *			X
11. DOS/Windows Compatibility		X	
12. Pen Compatibility		X	
13. User Defined Reports			
14. Multi-User System			
15. Wireless Data Transfer *			

Table 21. Sentel Corp. Air and Space Division viability evaluation.

Viability Criteria	Values	Points
Employees	202	3
Locations	6	3
Customer Base*	FG / PI	2
Diversification	Yes	1
Inhouse Research and Development	Yes	1
Average Annual Sales Last 5 Years	11,228K	4
Average Annual Profit Last 5 Years	-209K	-2
Current Debt to Asset Ratio	0.187	2
Organizational Age	9	2

Viability Total Score: 16

Hyper Project, Inc.

Donald Kasper, President 12356 Jollete Avenue, Granada Hills, California 91344; telephone (818) 831-0404; fax (818) 366-1769.

Table 22. Evaluation of Hyper Project, Inc. submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc			
2. User Added Data Tables			
3. Design Quality Checklists			X
4. Frequently Encountered Q/A Problems			X
5. Safety Procedures and Manuals			X
6. Keywords			X
7. Project Scheduling Data			X
8. Project Estimating Data			X
9. Environmental Compliance Checklists			X
10. Editable Computer Aided Design Overlays			X
11. DOS/Windows Compatibility		X	
12. Pen Compatibility		X	
13. User Defined Reports			
14. Multi-User System			
15. Wireless Data Transfer			

Table 23. Eiger Technical Systems viability evaluation.

Viability Criteria	Values	Points
Employees	6	1
Locations	1	1
Customer Base*	FG / SG / LG	3
Diversification	Yes	1
Inhouse Research and Development	Yes	1
Average Annual Sales Last 5 Years	1,100K	3
Average Annual Profit Last 5 Years	23%	2
Current Debt to Asset Ratio	0.26	0
Organizational Age	2	-1

Viability Total Score: 11

KPMG Peat Marwick, LLP

Robert V. Clint, 2001 M Street, NW., Washington, DC 20038; telephone (202) 467-3800; fax (202) 822-8887.

Table 24. Evaluation of KPMG Peat Marwick, LLP submission.

Evaluation Criteria	Yes	No	Unknown
1. Database; Dbase, Access, etc. *			
2. User Added Data Tables			
3. Design Quality Checklists			X
4. Frequently Encountered Q/A Problems			X
5. Safety Procedures and Manuals			X
6. Keywords			X
7. Project Scheduling Data *			X
8. Project Estimating Data *			X
9. Environmental Compliance Checklists			X
10. Editable Computer Aided Design Overlays *			X
11. DOS/Windows Compatibility		X	
12. Pen Compatibility			X
13. User Defined Reports			
14. Multi-User System			
15. Wireless Data Transfer *			

6 Combined Evaluation of Submissions

The final ranking was achieved by combining the scores from the evaluation table and the viability table. All respondents were evaluated using the same criteria. Each respondent was provided the same information—the CBD Announcement of 2 November 1994. No submissions were accepted after the end of the 45-day submissions period. Table 25 lists the respondents rated from high to low.

Table 25. Comparative scores.

Rank	Name	Evaluation Score	Viability Score	Total Score
1	Sentel Corporation	11	16	27
2	Integrated Planning Systems	8	16	24
3	Galaxy Scientific Corporation	6	10	16
4	Angle Incorporated	3	8	11
5	Eiger Technical Systems	-1	11	10
6	Pen Time Incorporated	-2	5	3

Screen Capture Comparison of Top Two Submissions

The submissions by Sentel and Integrated Planning Systems ranked first and second based on the evaluation process. The screen captures demonstrate the capabilities of the submissions more effectively then plain text or evaluation matrices.

Sentel Corporation

QAPDC's Test and Preparation (TAP) main screen (Figure 1) demonstrates that the application meets the criteria for DOS/Windows and pen compatibility because the application was running on a Compaq Concerto and pen-based notebook running Pen for Windows.

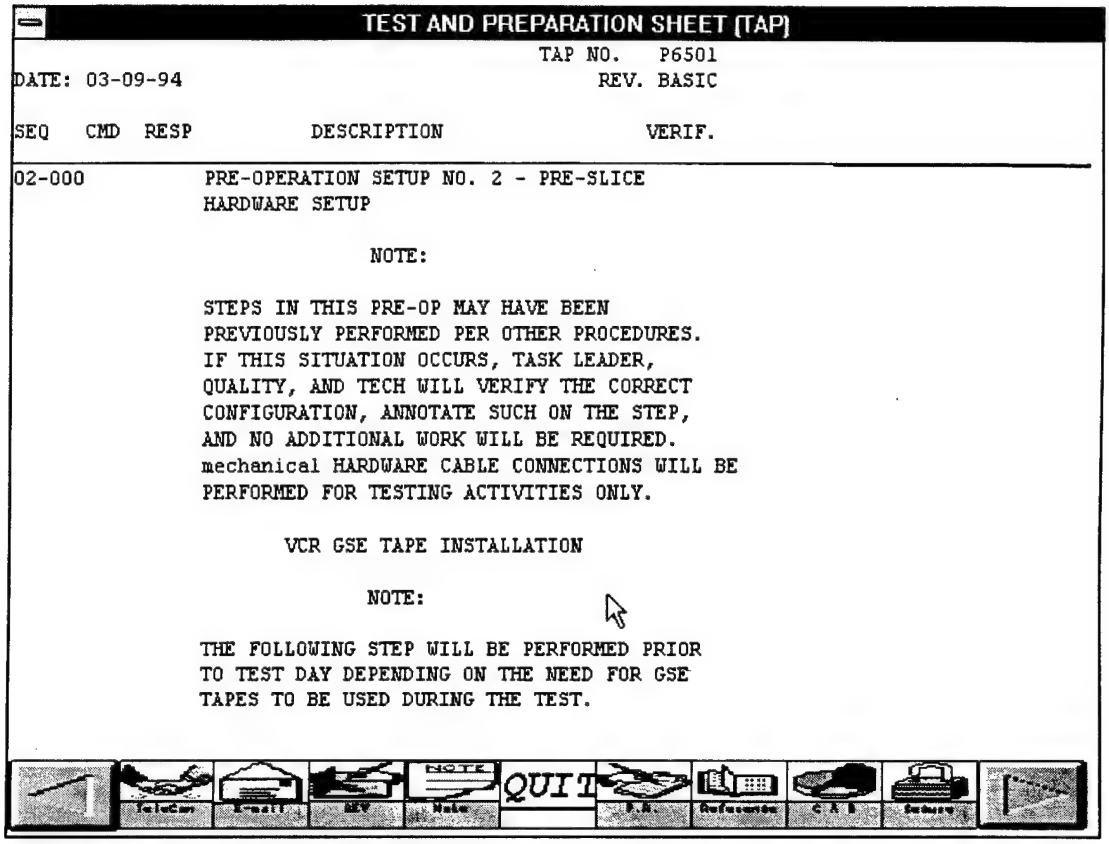

Figure 1. Test and Preparation Main Screen.

Editable CAD overlays can be accomplished in TAP by clicking on the Note icon at the bottom of the main page. The FieldNotes for Pens screen (Figure 2) is accessed. CAD-layered drawings can be imported so that a mark up layer, corresponding to the drawing layer, can be used to provide notes and edit comments.

Design Quality Checklists are available using the TAP Deviation Log screen (Figure 3). Several layers of information are available from this screen. The checklists provide required quality assurance reference material required for a particular job sequence.

The Deviation screen (Figure 4) allows the inspector to input the individual quality violations observed during the inspection. This screen is accessed directly from the Deviation Log screen.

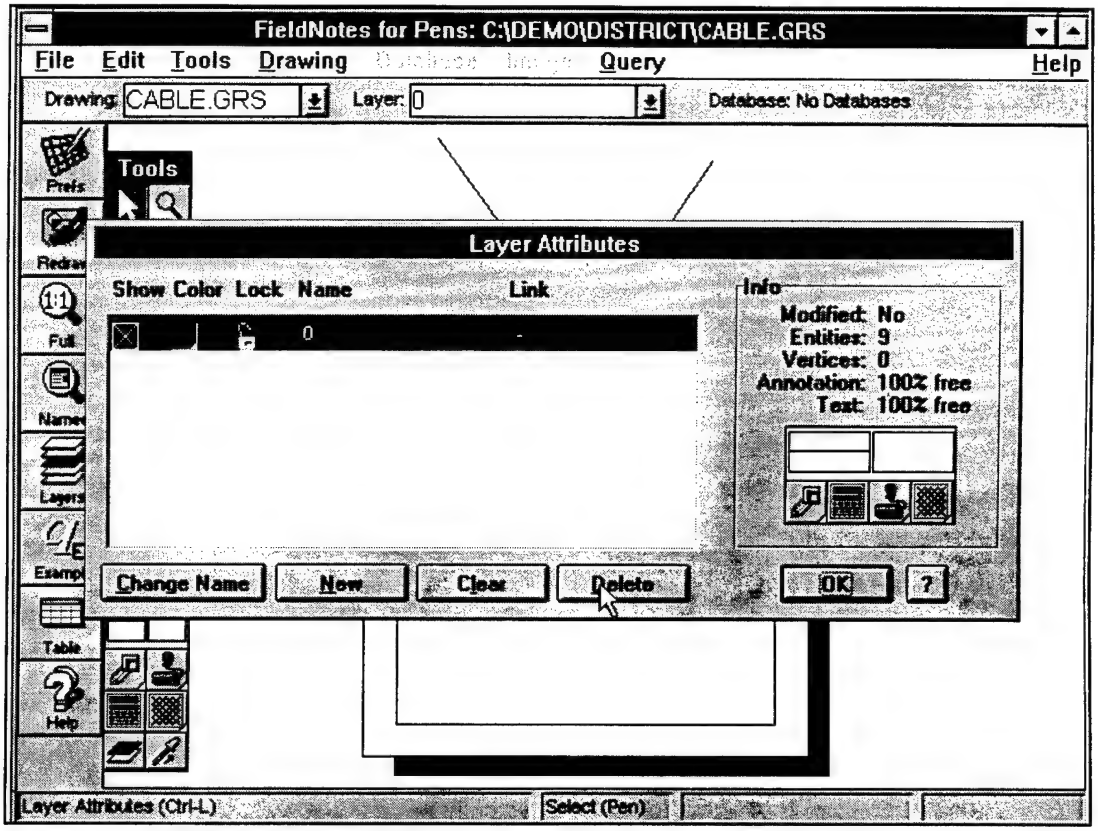

Figure 2. FieldNotes for Pens Screen.

TAP DEVIATION LOG

TAP NO: Page: 1 of 1

DEV. NO.	RUN NO.	DATE	Page	Sequence	P / T	QA
1	1					

Return to TAP

Figure 3. TAP Deviation Log Screen.

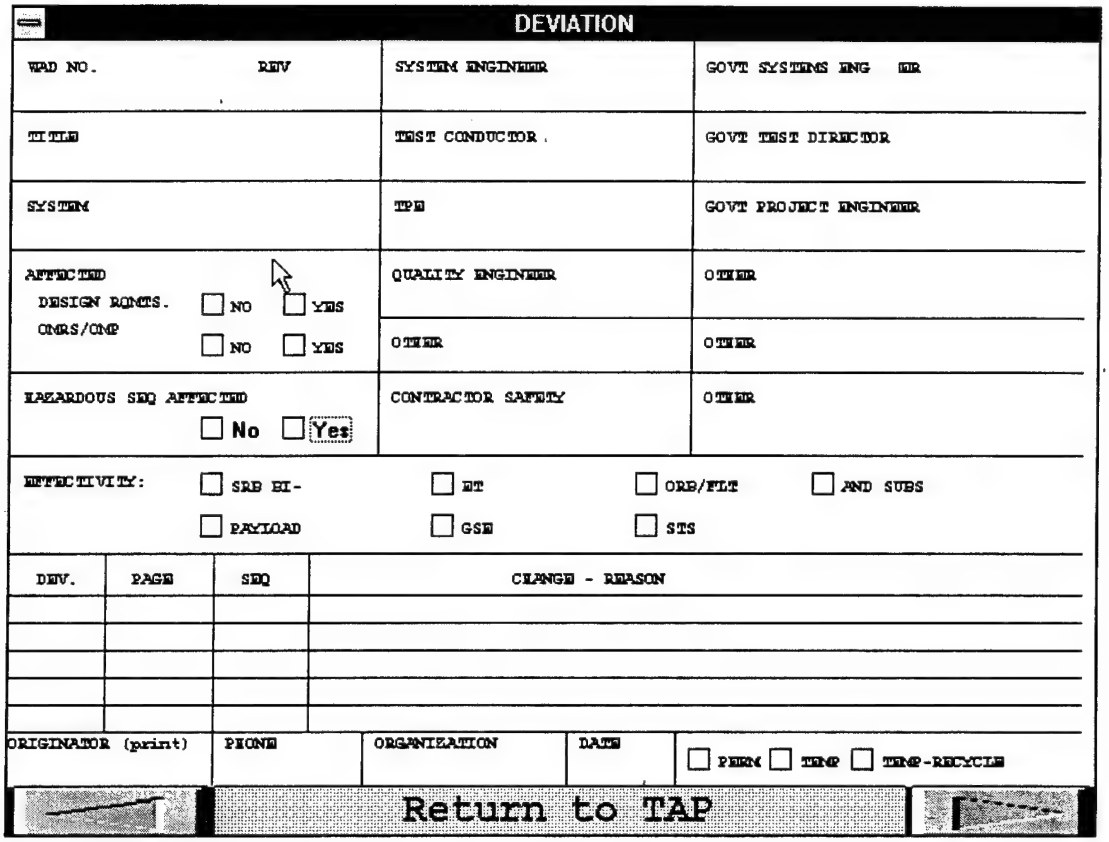

Figure 4. Deviation Screen.

The Reference Screen (Figure 5) provides information required to complete the Deviation Screen so that an inspector can justify a deviation report fully. This completes the quality assurance procedures used by TAP.

Safety Procedures and Manuals are provided by the Problem Report Screen (Figure 6) and its reference subscreens. Safety problems are input through the main Problem Report screen. This screen can be accessed at any time a problem is observed while using TAP.

The Reference Screen (Figure 7) provides the necessary safety data to define the scope of the problem and its severity. Emergency procedures for immediate action are also provided if required.

Project scheduling data are provided by the Scheduling Screen (Figure 8), which is accessed depending on the inspection being performed. Project Estimating Data is also available, but not in the demonstration submitted. The estimating data structure has to be populated and the user has to have clearance to access the data before the screen can be accessed.

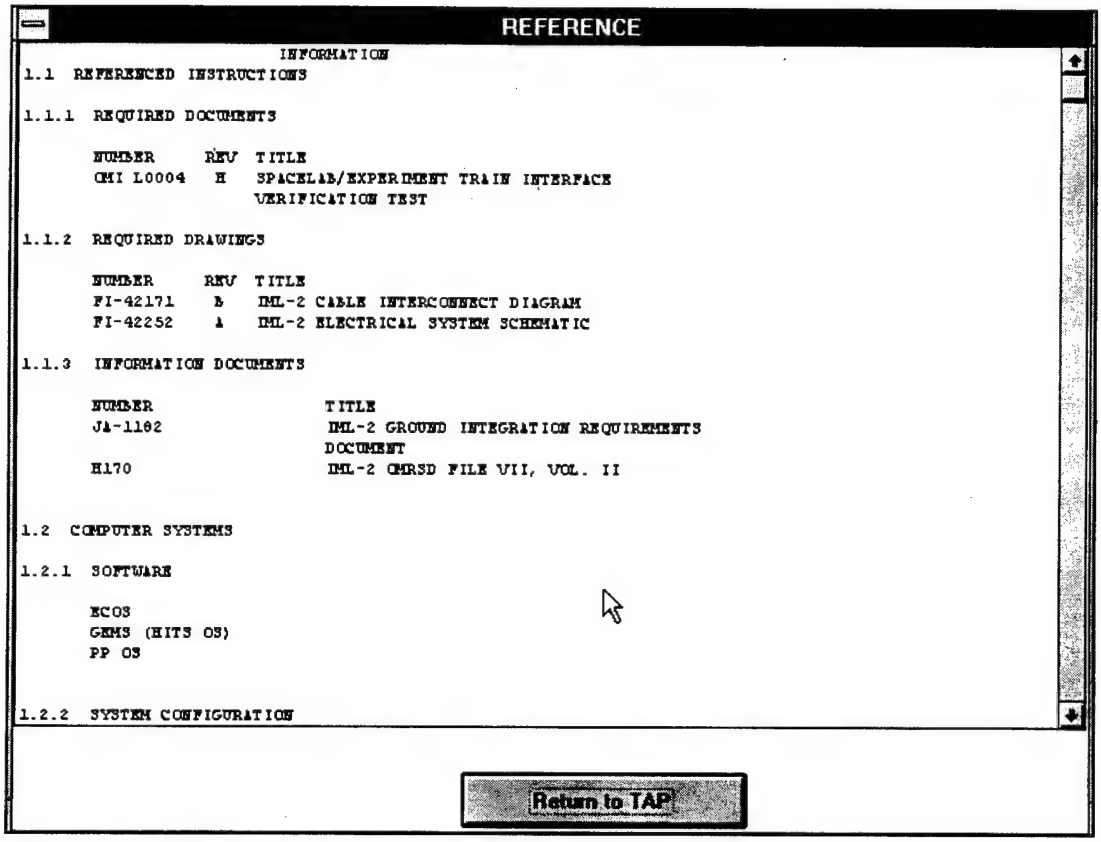

Figure 5. Deviation Reference Screen.

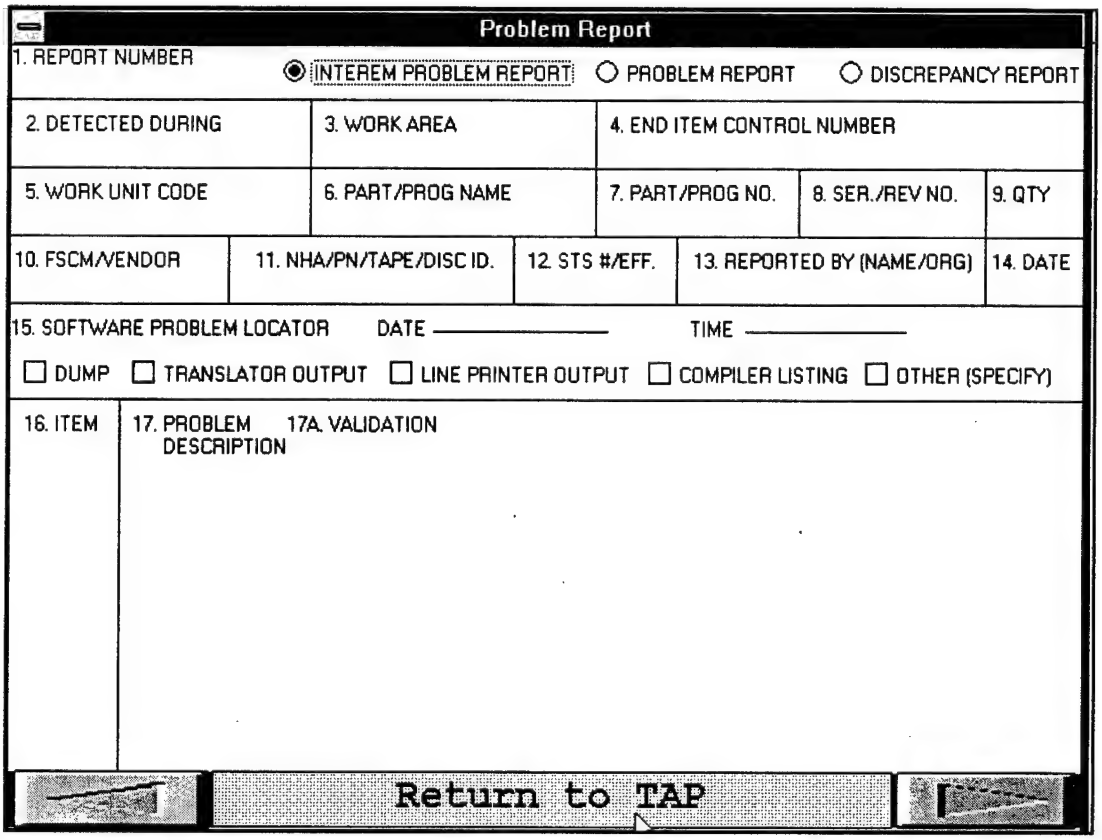

Figure 6. Problem Report Screen.

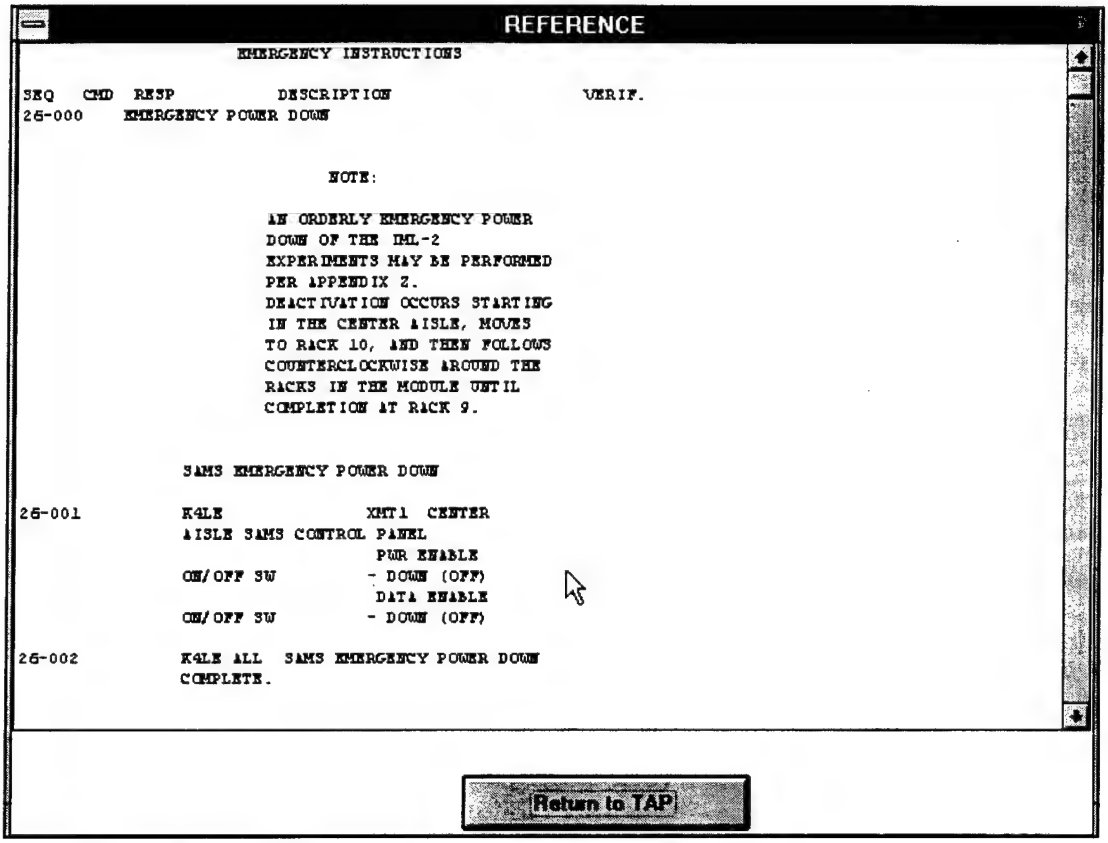

Figure 7. Emergency Procedures Reference Screen.

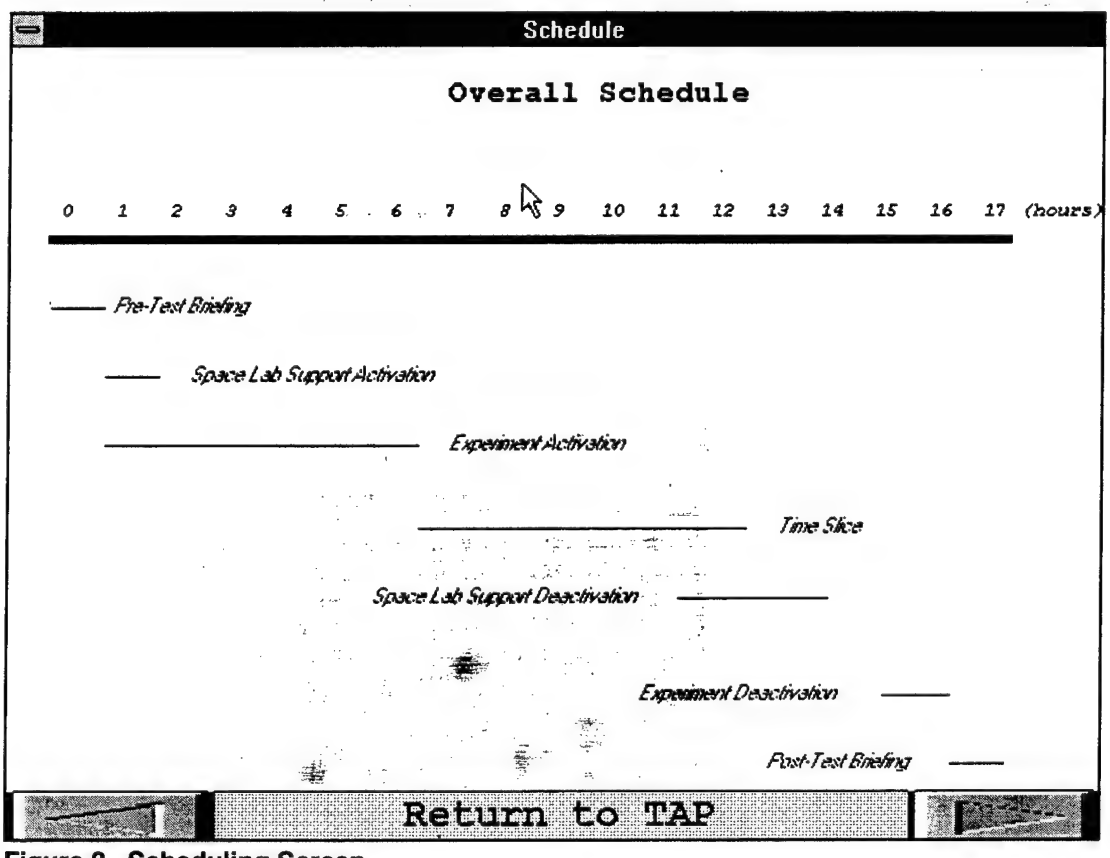

Figure 8. Scheduling Screen.

Figure 9 shows the main screen of the Facility Condition Assessment System (FCAS), which was the second application submitted by Sentel Corp. It provided functionality that was not available in TAP.

When the inspector taps or clicks on one of the locations on the Facility Locations Map Screen (Figure 10), automatic links to reference data and inspection requirements are invoked relating to the specific installation.

After chosing Deming, Arizona for this screen capture, a Report screen (Figure 11) appears with the location already populated with the correct name.

Environmental Health (Figure 12) and Maintenance (Figure 13) checklists are accessed from the menu at the top of the Report Screen. As these checklists are populated by the inspector, they are specifically linked to the inspection report being generated. The checklists are based on reference data stored in the database for the chosen location.

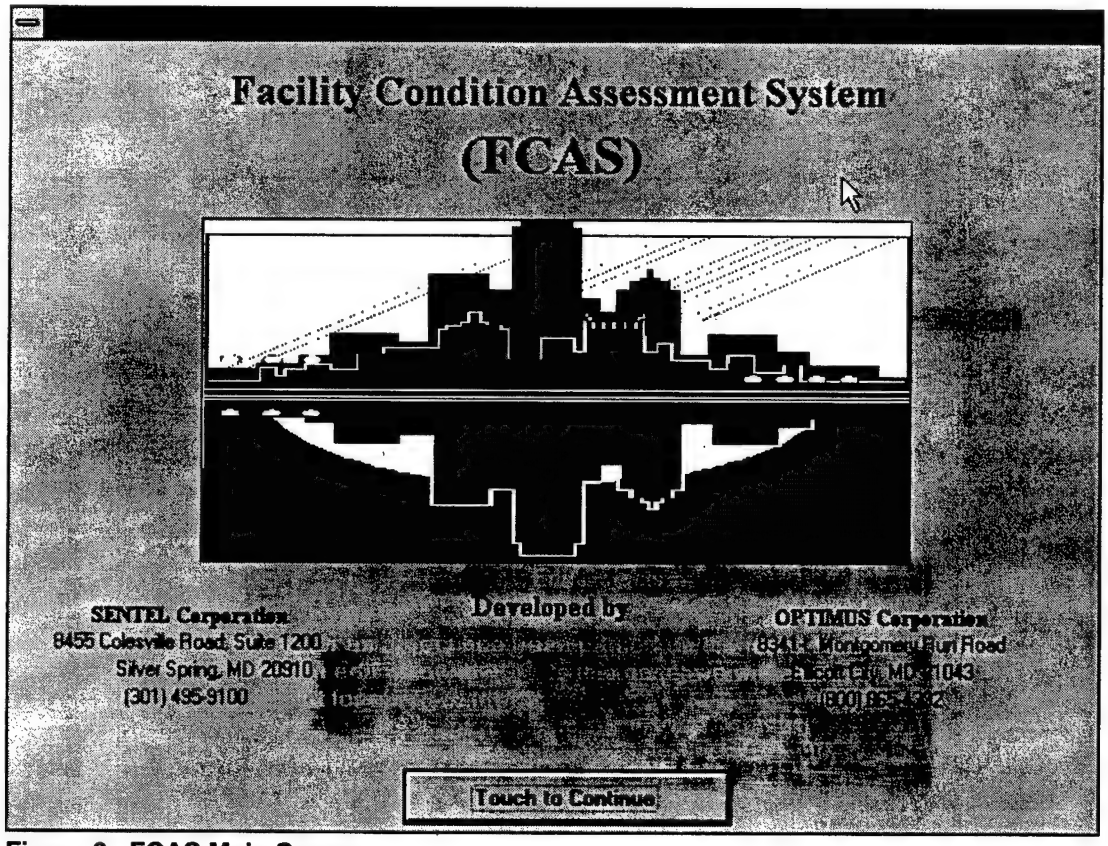

Figure 9. FCAS Main Screen.

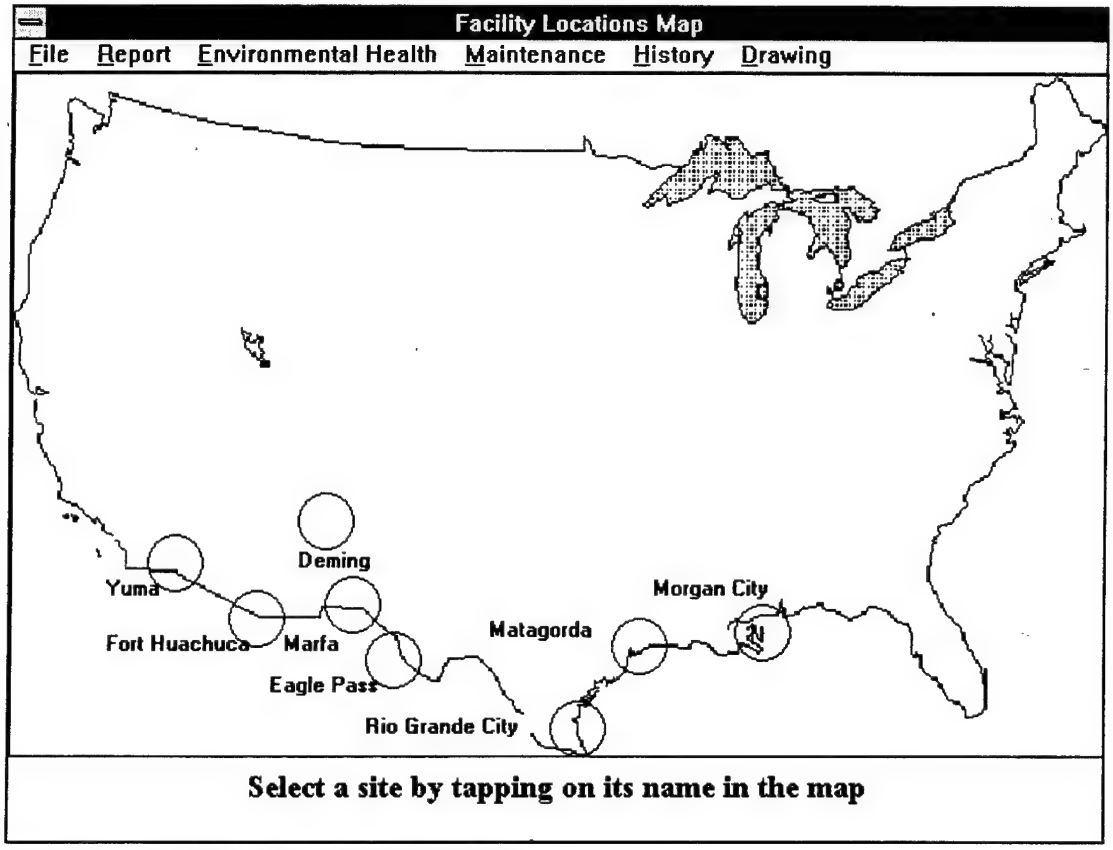

Figure 10. Facility Location Map Screen.

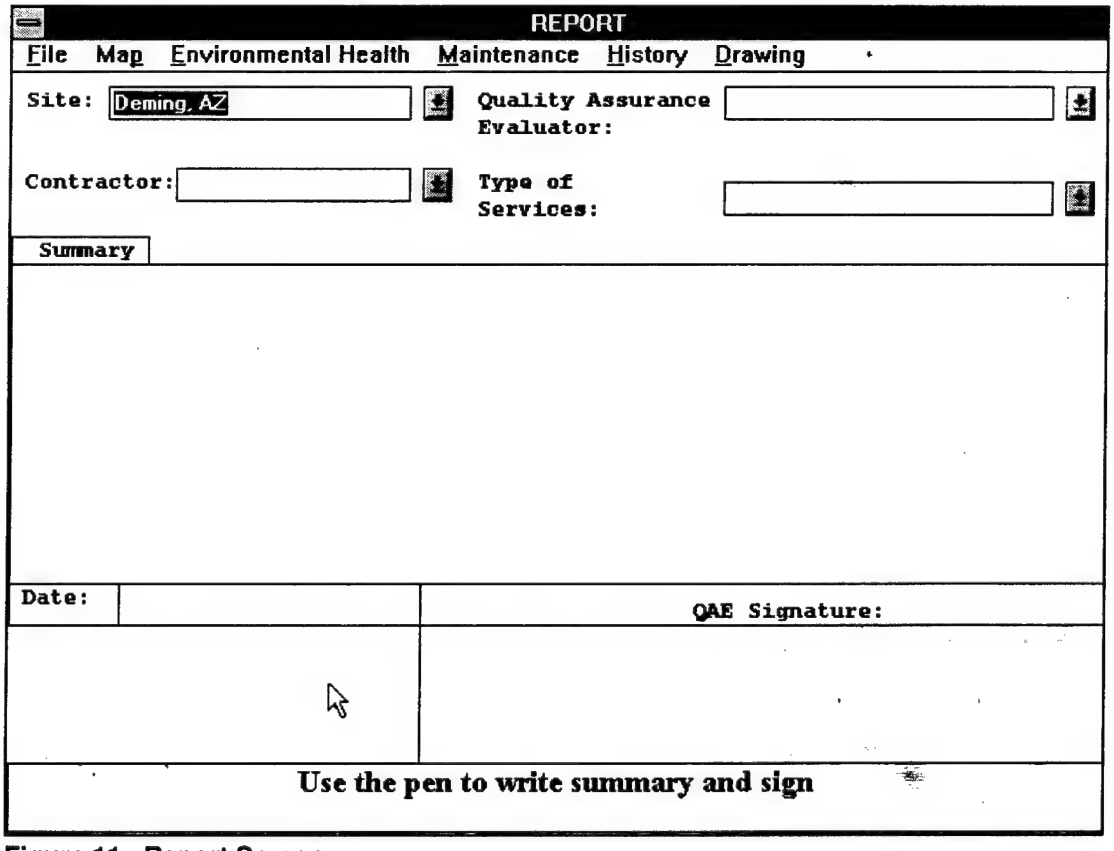

Figure 11. Report Screen.

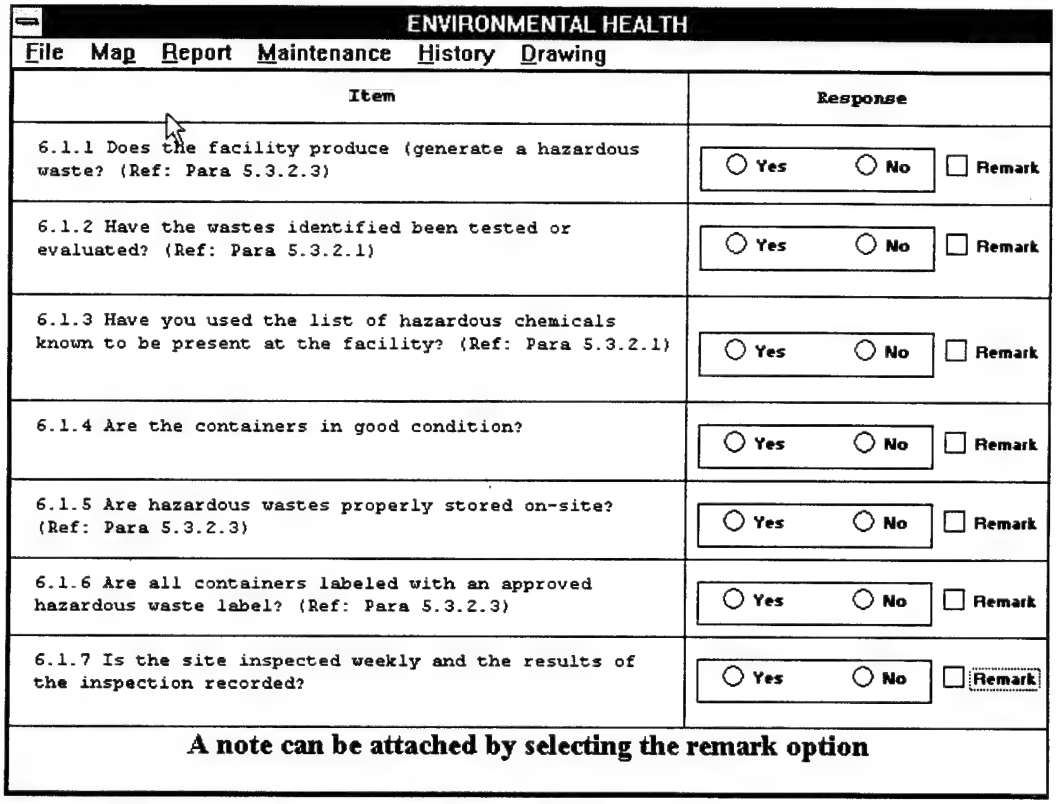

Figure 12. Environmental Health Checklist Screen.

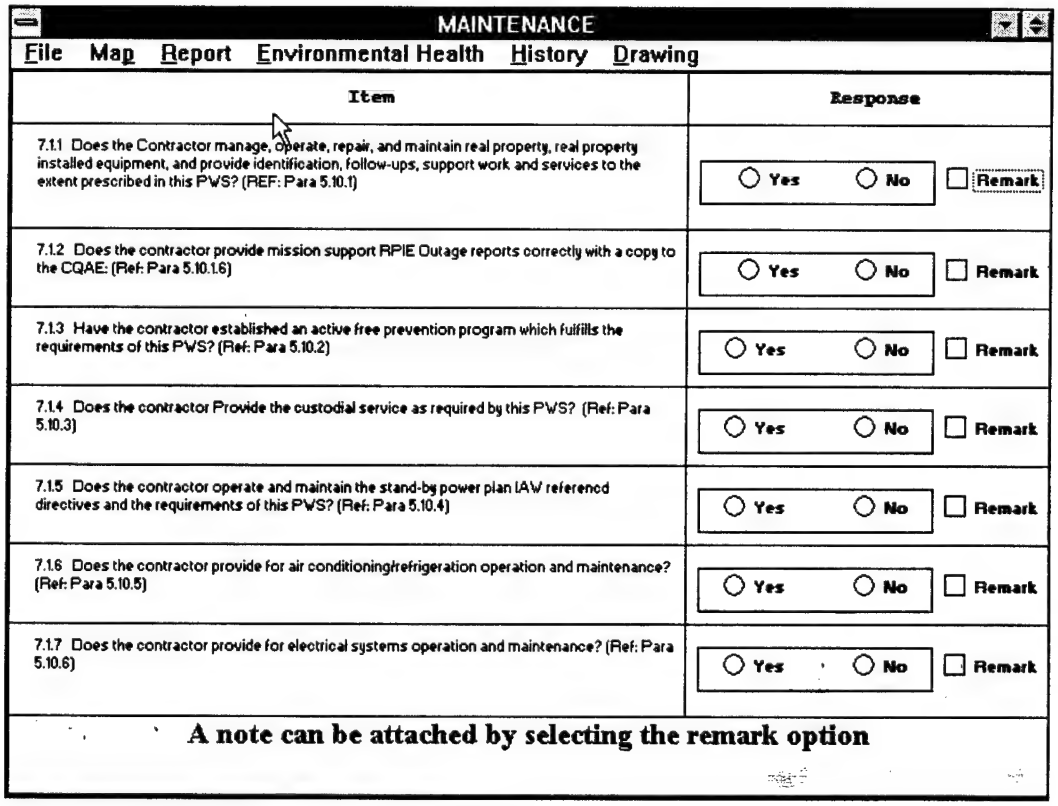

Figure 13. Maintenance Checklist Screen.

As with TAP, the FieldNotes for Pens screen (Figure 14) is available for written input related to the inspection.

The History screen (Figure 15) provides access to data input from previous inspections. This access allows inspectors to review a location's compliance to regulations and standards and determine whether corrections have been made.

Integrated Planning Systems

GeoFirma is a canned demonstration that steps through the process required to develop an inspection entry form and then use the form to collect inspection data. As the form is developed, a database is simultaneously developed to allow the required data entry. The demonstration proves that the application is DOS and Windows compatible. The data entry form development process also demonstrates the database requirement.

GeoFirma's FieldPack Designer allows the user to develop required data entry inspection forms with a number of data entry fields that can be user defined. As shown in Figure 16, the small window is the demonstration operator that displays information pertinent to the screen being displayed and allows the viewer to continue the demonstration.

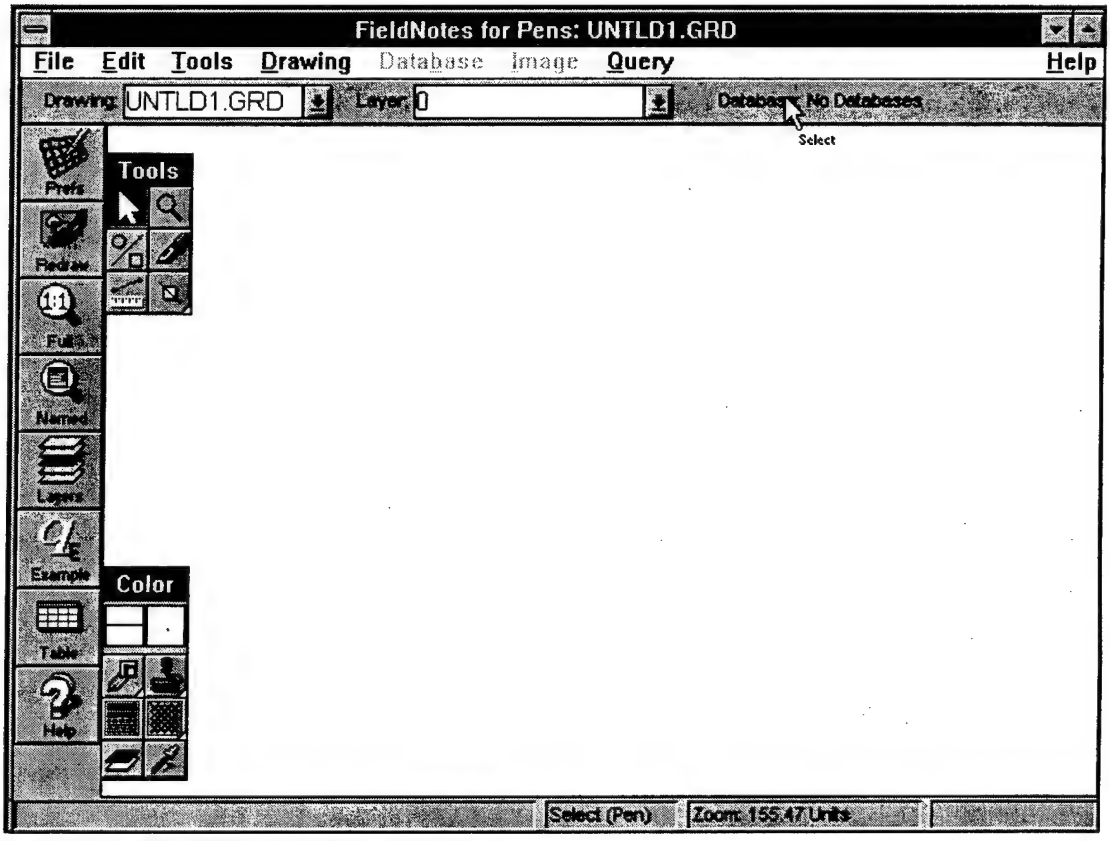

Figure 14. FieldNotes for Pens Screen.

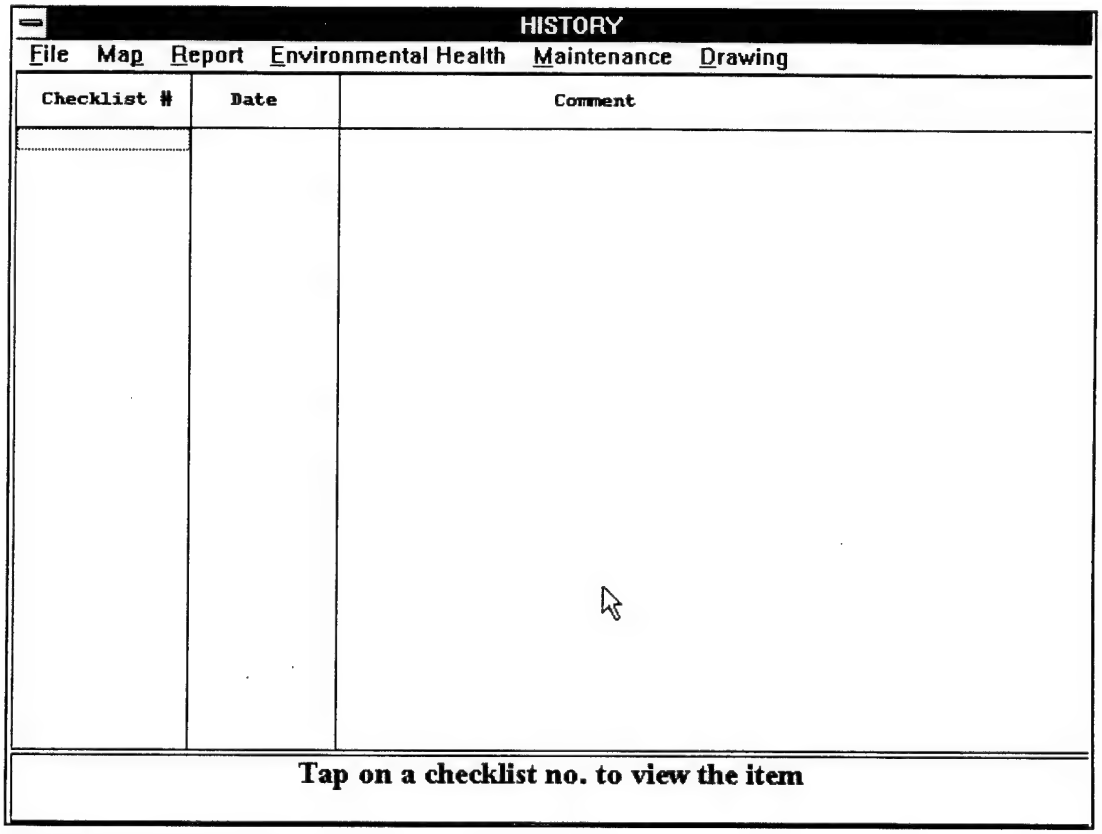

Figure 15. History Screen.

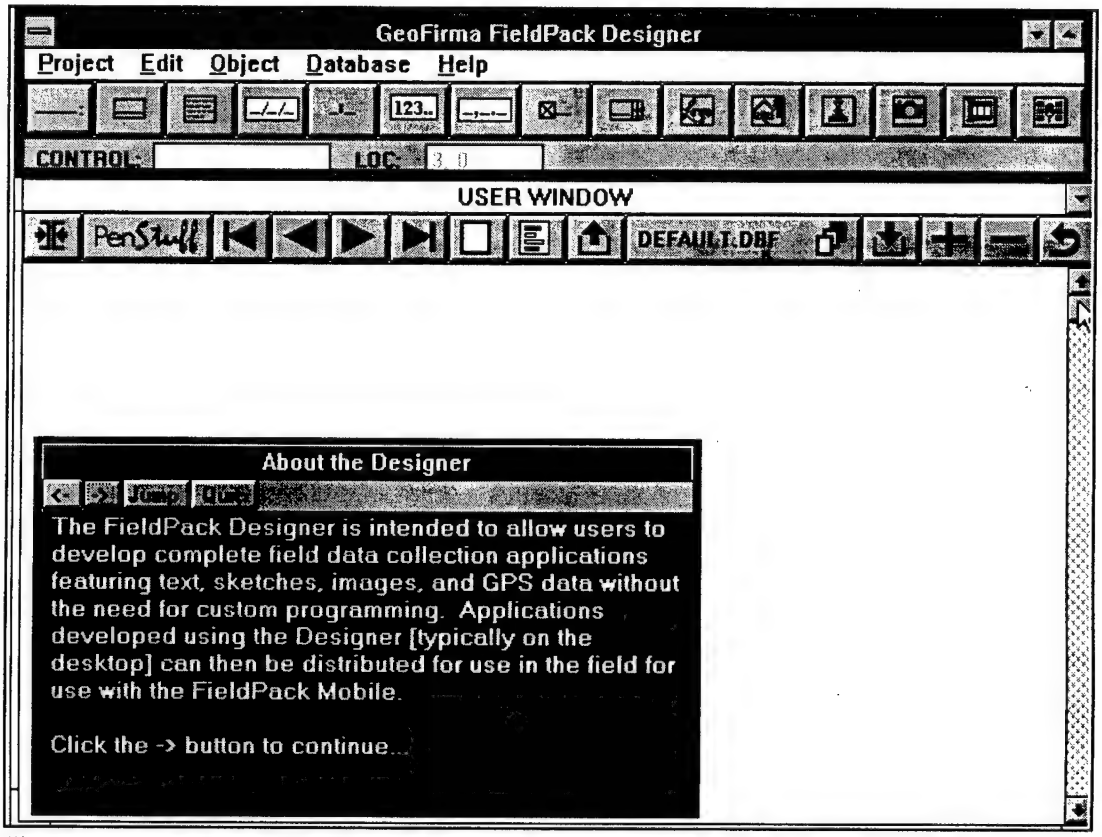

Figure 16. GeoFirma FieldPack Designer Screen 1 showing the demonstration operator box in the lower lefthand corner.

Figure 17 shows Screen 2, where static text on the form is created using a dialogue box. The text can be entered using either a keyboard or pen.

A variety of input fields can be defined to allow text, number, or menu choices. Screen 3 (Figure 18) displays the string box that permits the entry of text strings.

Screen 4 (Figure 19) shows the creation of a numeric input field. The field is capable of accepting decimal, percentage, or monetary values.

Digital images can be entered using the form by placing an image field on the form. Pictures can then be scanned into the data base, stored in a variety of image formats, and displayed. Multiple frames called a film strip can also be stored. Signature fields are where the form is signed. Screens 5 and 6 (Figures 20 and 21) show the icons that represent these fields.

When the entry screen shown in Figure 21 is complete, all required functional controls are available to the user at the top of the form. Search and retrieval of data are included in the input screen functionality.

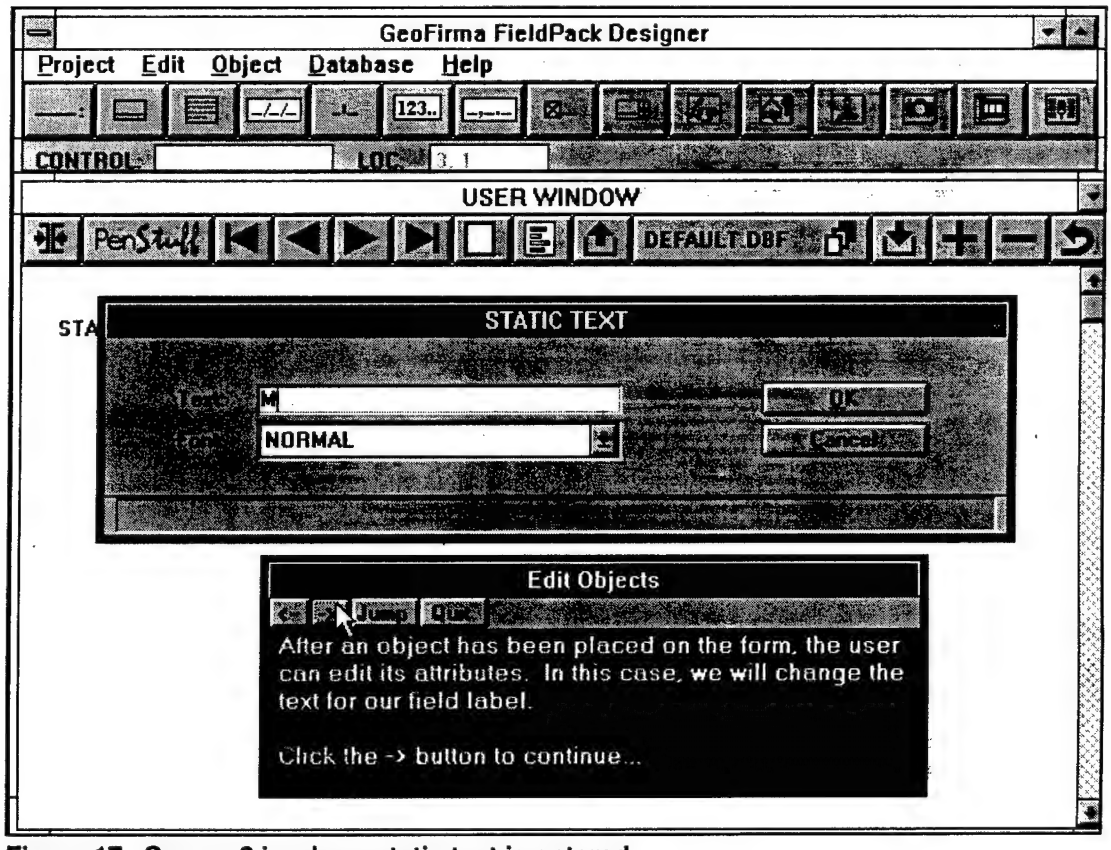

Figure 17. Screen 2 is where static text is entered.

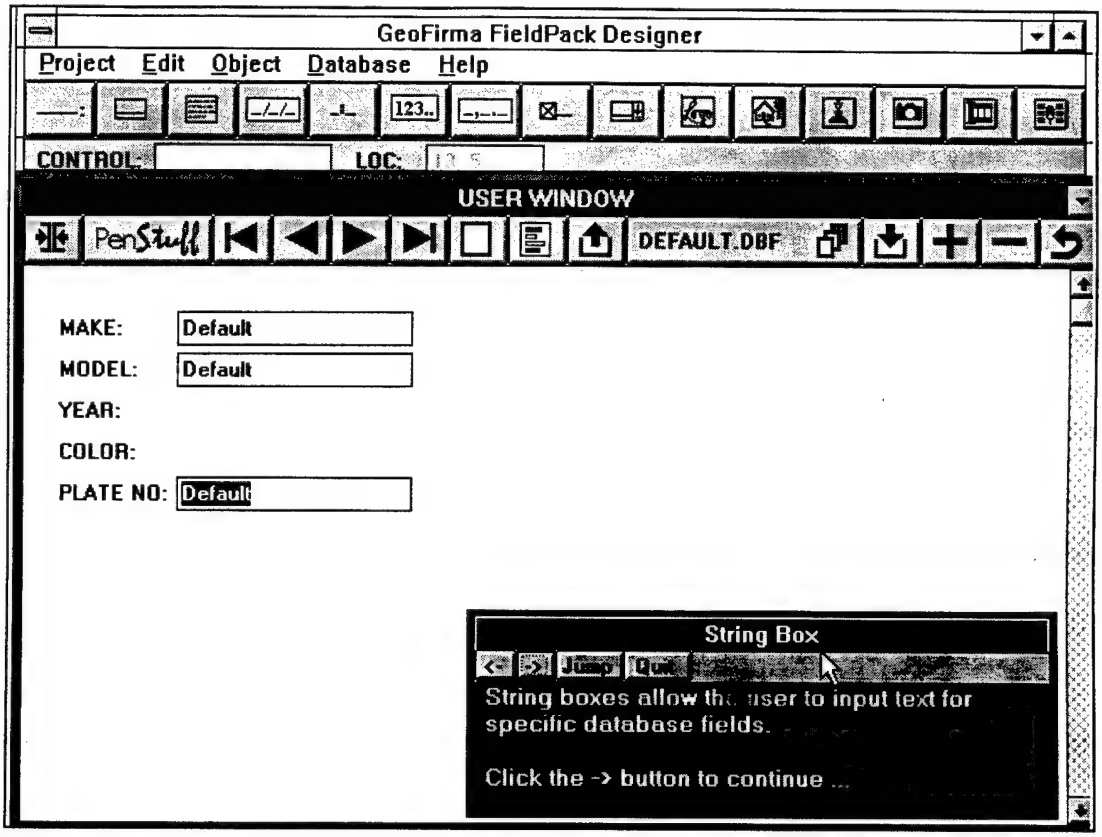

Figure 18. Screen 3 is where text strings can be entered.

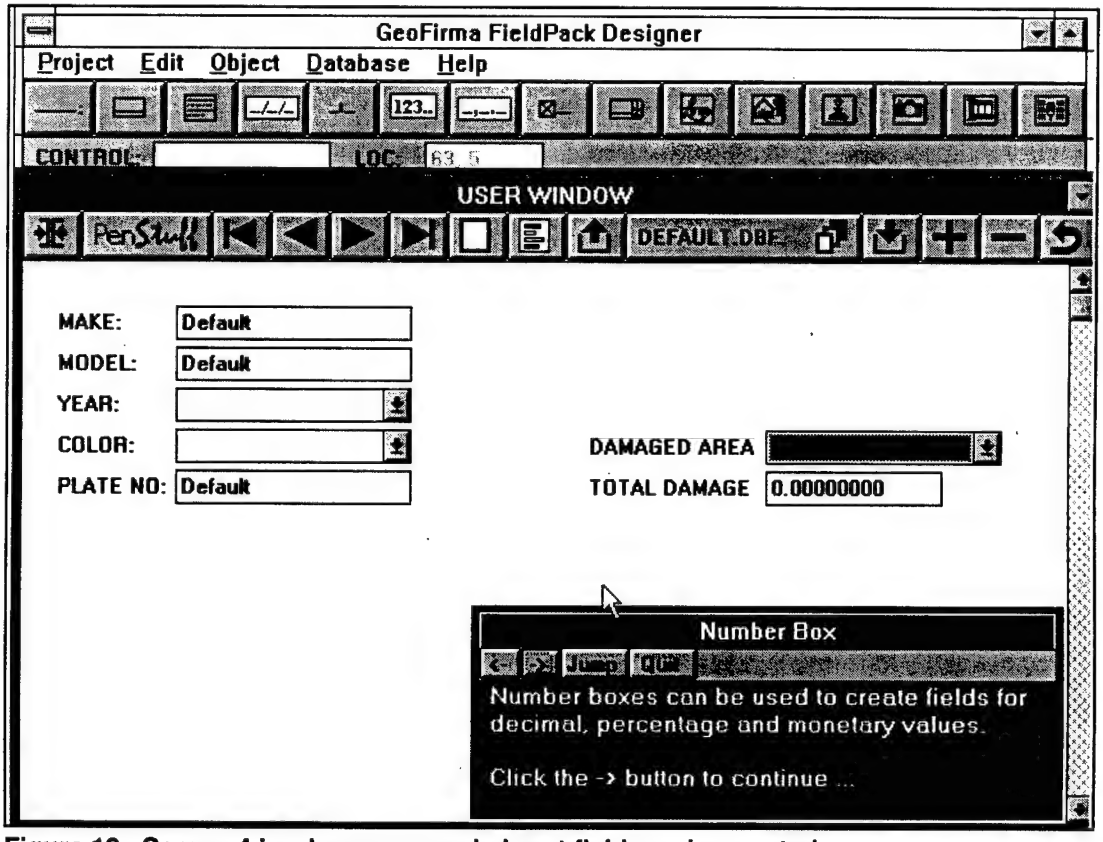

Figure 19. Screen 4 is where a numeric input field can be created.

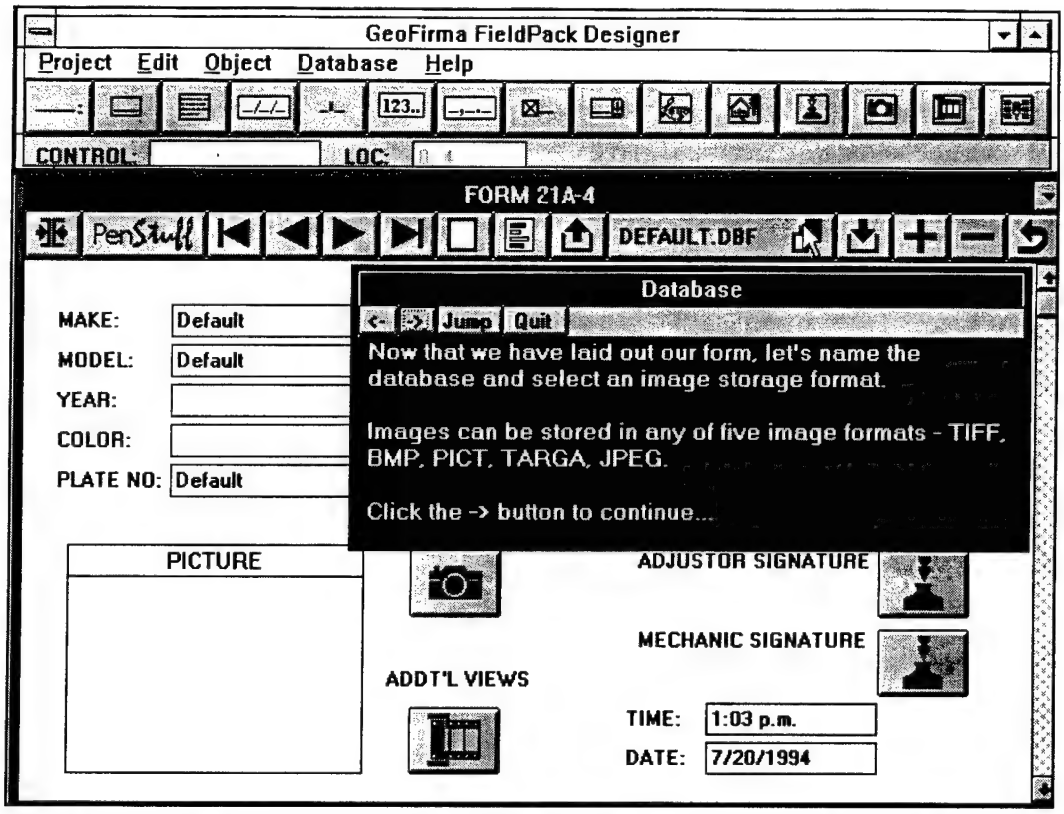

Figure 20. Screen 5 shows icons to plae digital images, store film strips, and place signatures on the form.

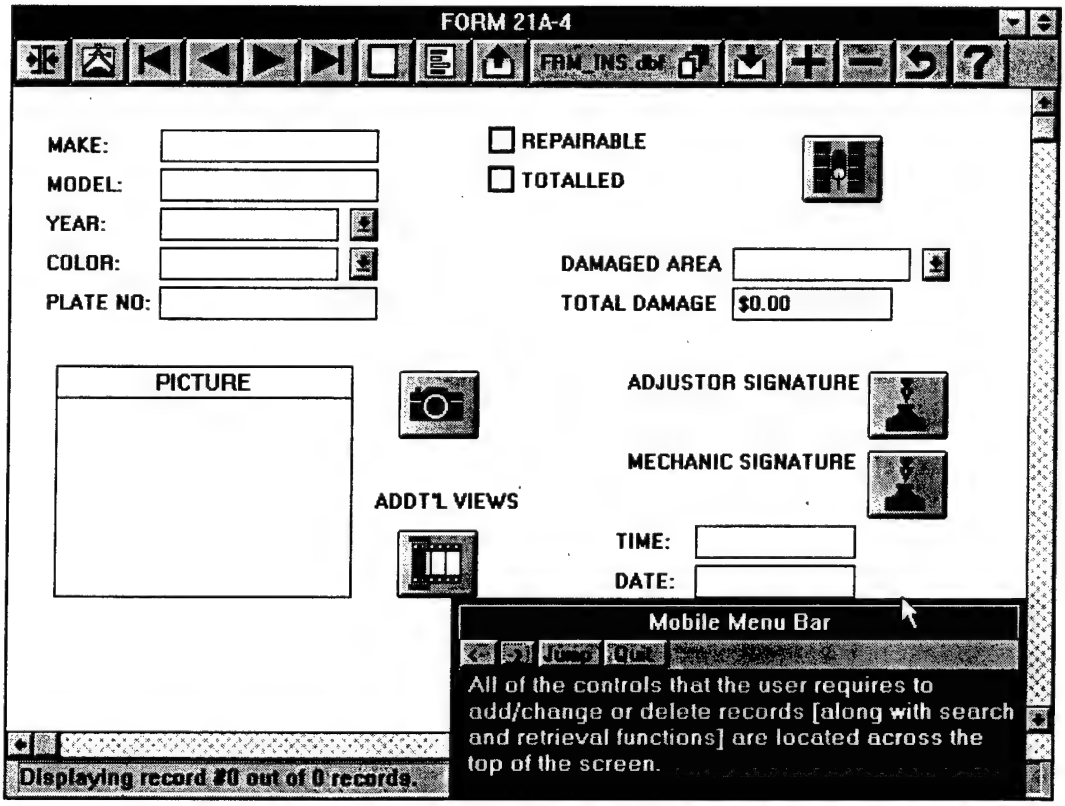

Figure 21. Screen 6 shows more detail of the available icons.

The second part of the demonstration concerns physical data collection using the input screen. When the record is saved, the database is populated according to field definitions.

Figures 22 through 27 show the data collection process using the fields defined previously and using (1) direct-typed or pen-written input, (2) pull-down menu, signature, video, or scanned-picture input, and (3) global positioning satellite (GPS) input.

Pull-down menus based on definitions created during the design facilitate data entry. Check boxes are used where simple choices are needed as in Screen 8 (Figure 23).

The numeric input related to damage estimates demonstrated in Figure 23 allows for data storage of values that can be used for direct numeric calculation later.

Date and time are added automatically to their respective fields. The location of the inspection is input by using the GPS button, which makes a direct satellite reading for the required input. Screen 10 (Figure 25) displays the satellite data collection input process after the GPS button has been pressed. The location is fixed when the coordinates are displayed and the icon smiles.

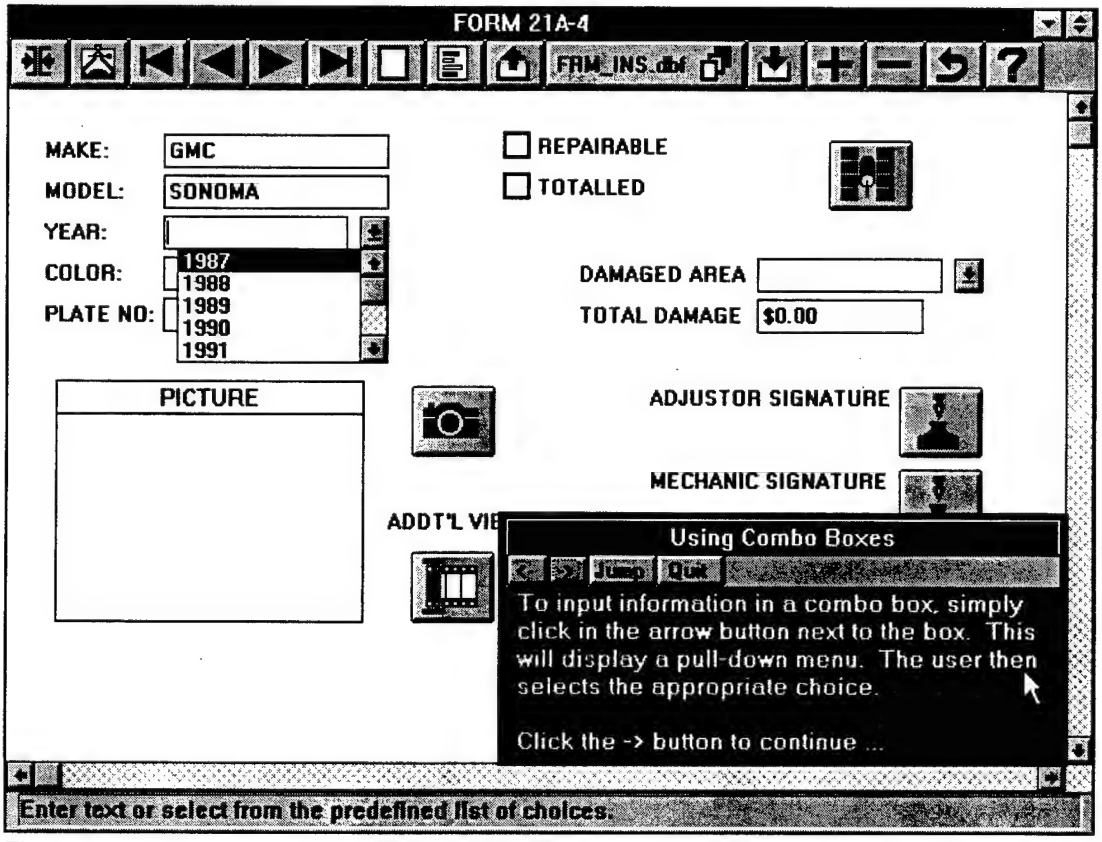

Figure 22. Screen 7 shows the first step in the data collection process.

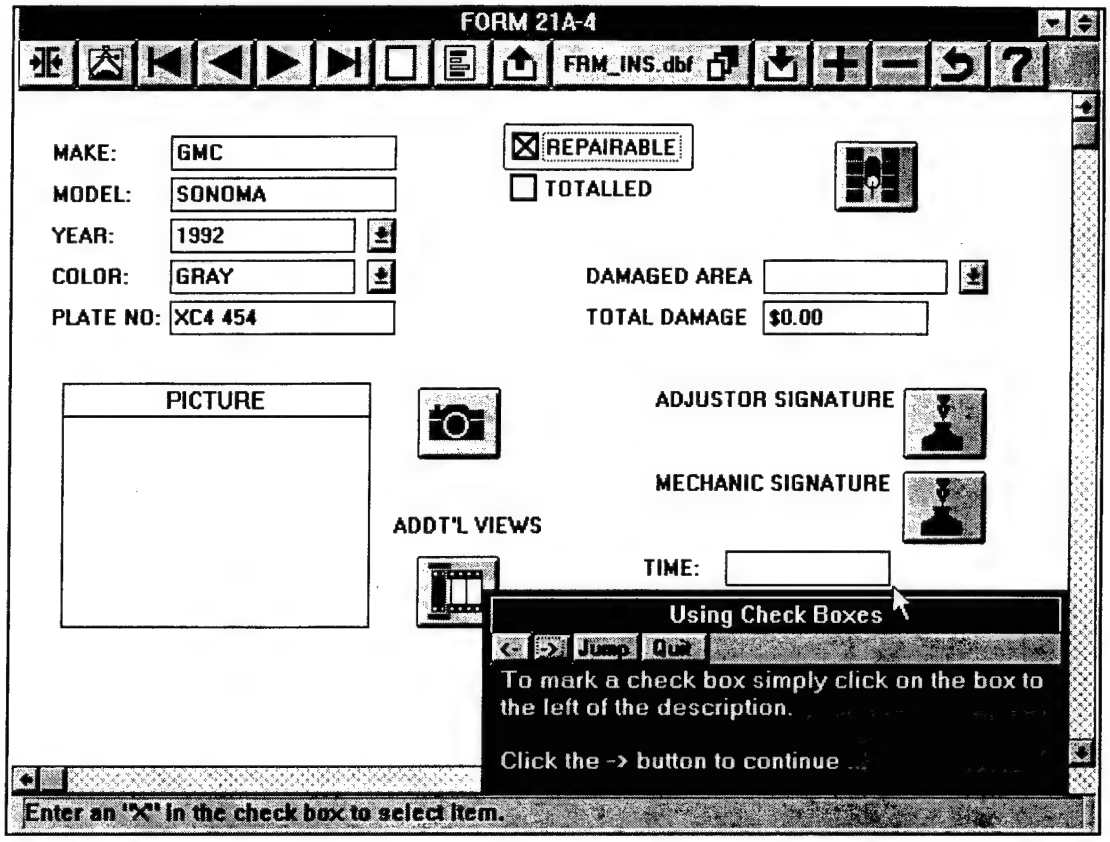

Figure 23. Screen 8 shows data entry of damage estimates.

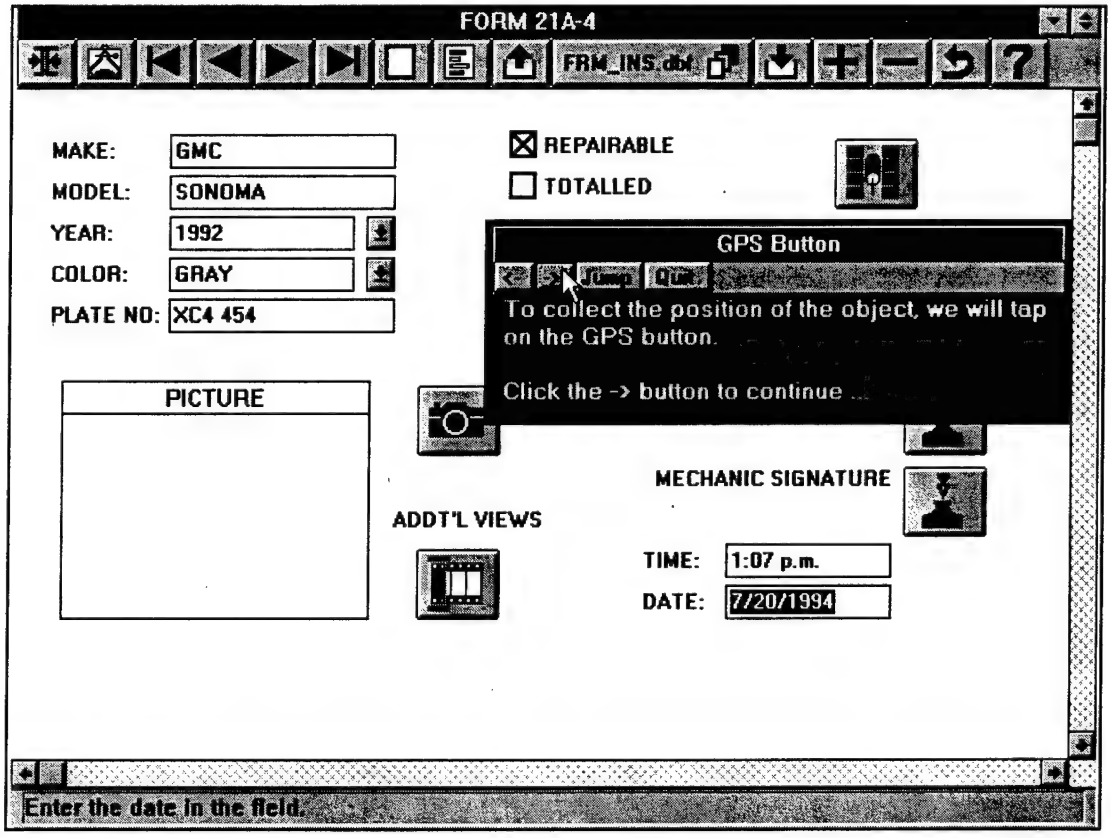

Figure 24. Screen 9 shows the procedure for locating the inspection site with global positioning.

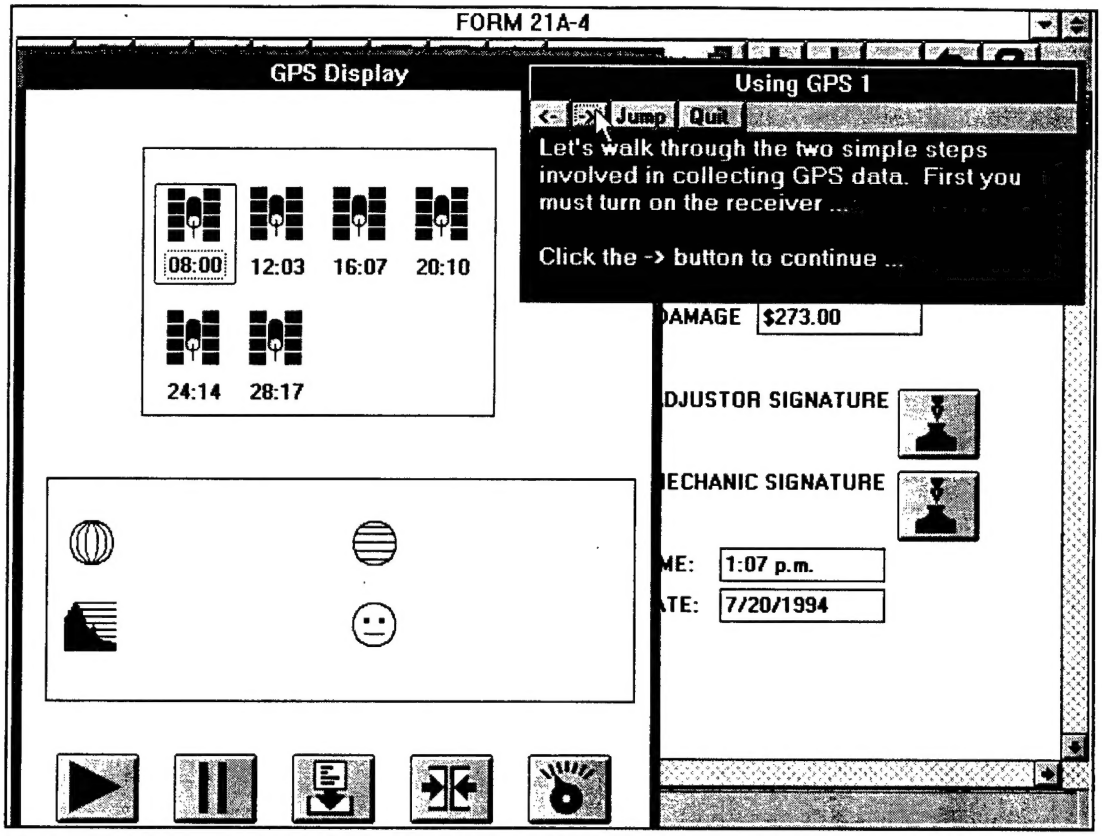

Figure 25. Screen 10 displays the satellite data collection process after the GPS button is selected.

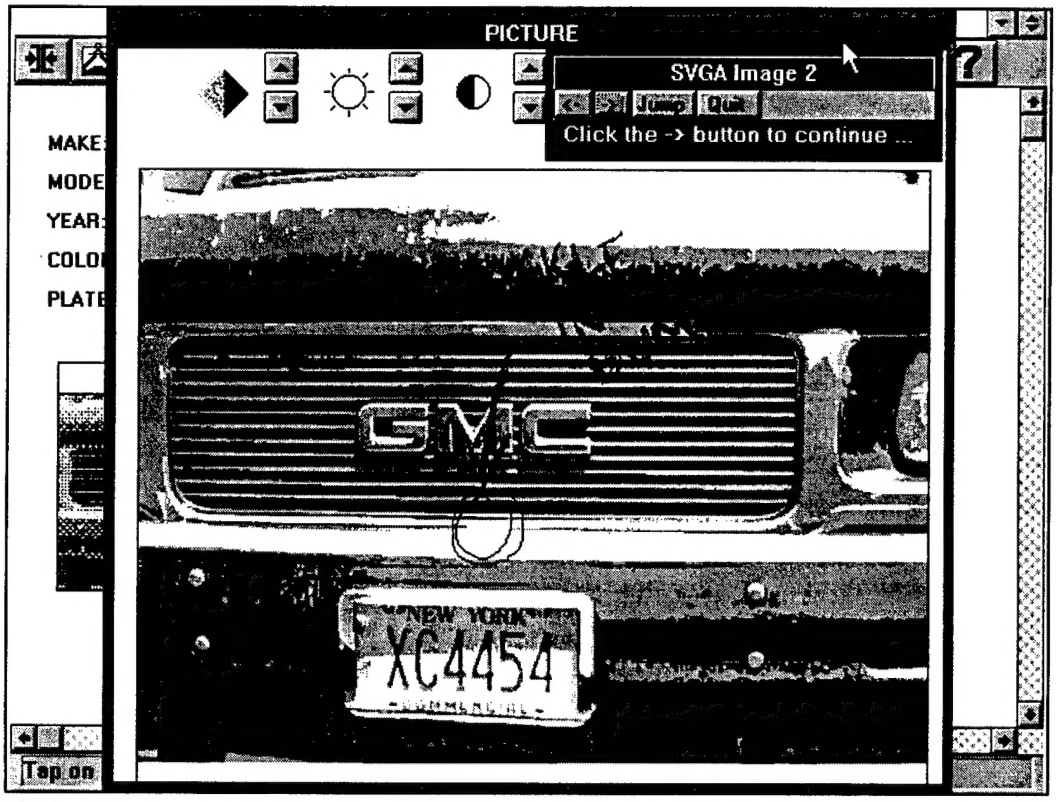

Figure 26. Screen 11 shows a marked up graphical image.

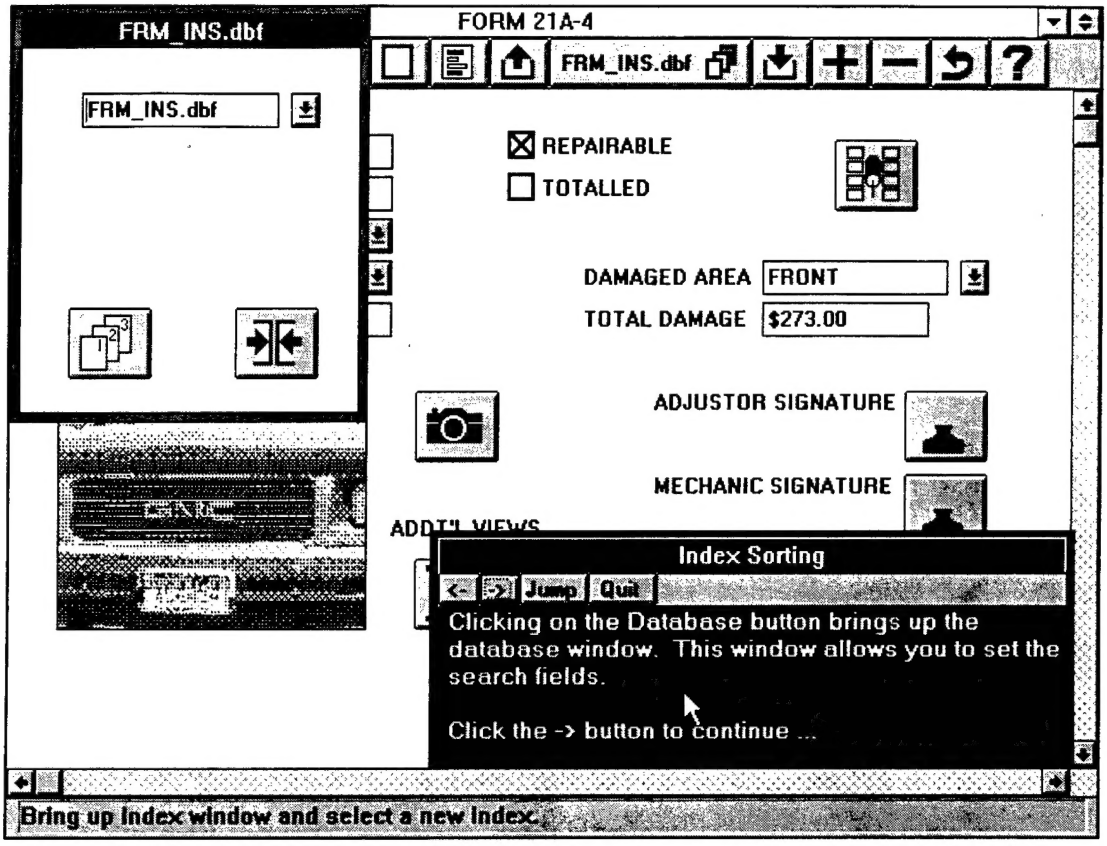

Figure 27. Screen 12 shows the dialogue box used for keyword searches related to repair data.

Graphical images can be marked up as shown in Screen 11 (Figure 26) to indicate damage or repair sites. This process is accomplished by clicking on the drawing button at the top of the input screen. This process was considered equivalent to being able to mark up layer drawings.

Clicking on the database button at the top of the input screen allows a keyword search of the key database fields using the dialogue box in Screen 12 (Figure 27).

7 Summary and Conclusion

Summary

The object of this project was to determine the availability of pen-based computer applications related to the field of quality assurance and evaluate the level of pen-based programming expertise among the organizations currently marketing this kind of software. A Sources Sought Notice for a Pen-Based Construction Quality Assurance Application placed in the CBD was used to identify vendors of pen-based applications with features that could be evaluated against the criteria presented in the announcement. Potential respondents were instructed to submit a demonstration diskette of a current pen-based inspection application and a synopsis of the organizational structure and knowledge base.

The evaluation process determined (1) each responding vendor's ability to provide a product meeting the required criteria for a quality assurance application and (2) their financial stability. Two vendors, Sentel Corporation and Integrated Planning Systems, Inc., were identified as having applications that were superior in content and development and having strong market positions. A three-point difference separated these two vendors. Scores for both Sentel and Integrated Planning Systems were 50 percent higher than the next closest vendor, Galaxy Scientific Corp.

Conclusion

The level of expertise required for the development of functional pen-based systems was found to be readily available in the open market. The response generated by the CBD announcement and the evaluation of the subsequent submissions indicates that properly prepared Statements of Work and Cooperative Work Agreements would lead to a pen-based application capable of meeting Corps of Engineers' requirements for a Construction Quality Assurance Management software system for both office and field.

If funded, a future phase of this research will be to develop specific technology transfer activities based on these survey results. Phase 3 will include the delivery of these programs through ISU's CTTC.

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